and

CORE

Sky and TELESCOPE

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CHARLES A. FEDERER, JR., *Editor* HELEN S. FEDERER, *Managing Editor*

The Editors Note . . .

AN anniversary of interest to everyone concerned with astronomy occurs on May 24, 1943, marking the 400th year of the death of Copernicus. Last fall the Kosciuszko Foundation (for the promotion of intellectual and cultural relations between Poland and the United States) began planning for a nationwide celebration of the date which "popularly marks the birth of modern science and more specifically of modern astronomy."

Schools, libraries, and planetariums will hold lectures, exhibitions, and commemorative celebrations. Many amateur groups may also wish to mark this significant occasion in some way. A beautifully printed and illustrated brochure, just published by the Foundation, is available from them at 149 East 67th St., New York City, for 75 cents. It gives information about the great Polish astronomer and numerous suggestions for programs, dramatizations, and exhibits.

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Press date for *Sky and Telescope* was advanced a full week beginning with the February issue, in order to overcome the greatly increased time for transmission in the mails. This may sometimes delay publication by us of news of astronomical events occurring at certain times; for instance, on our new schedule, Nova Puppis would have appeared too late to have been covered in our December number.

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Incidentally, Nova Puppis is still a subject for amateur observation, as is also Whipple's comet; for notes on both these objects, see the "Observer's Page." As the front cover shows, the comet's tail is faint, but it extends clear off the plate; smaller-scale photographs show the tail's length to have been eight degrees or more.

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And our back cover, the full moon, reminds us that this year Easter comes at its latest possible date, April 25th. To predict the date correctly, certain principles in determining the *calendric* full moon (which rarely coincides with the real astronomical event) must be followed, in combination with the rule that Easter is "the Sunday after the 14th day of the new moon that falls on or after the 21st of March." This is quoted from The SKY, June, 1939, under "Epochs and Eras," an interesting series of notes on chronology by Wm. H. Barton, Jr.

50 YEARS OF POPULAR ASTRONOMY

The January, 1943, issue of *Popular Astronomy* is a jubilee number, containing the history of the magazine and many letters of congratulation to the editors. *Popular Astronomy* is the third generation of a line of magazines attempting to disseminate astronomical information. The first generation, the *Sidereal Messenger*, founded by William Wallace Payne, of Carleton College, made its initial appearance in 1882. It served its purpose well for 10 years. Then a need was felt for a journal that would publish research results of interest to the professional astronomer as well as more popular material for the layman. Prof. Payne would continue his work in the latter interest, while Prof. George Ellery Hale, of Kenwood Observatory, would take care of the more technical material. Thus the second generation, *Astronomy and Astrophysics*, came into being. Three thick volumes were published in 1892-94. But, meanwhile, it had become evident that too much material was available, and it was decided again to separate the more popular from the more advanced papers. *Popular Astronomy*, one member of the third generation, first appeared in September, 1893. The other member is the *Astrophysical Journal*, which first appeared under that title in 1895.

During its 50 long years, *Popular Astronomy* has served its purpose very effectively. Perhaps its greatest service has been to the amateur astronomer, whose observations and problems occupy an appreciable portion of the journal, notably in the monthly reports of the recorder of the American Association of Variable Star Observers, in Meteor Notes from the American Meteor Society, and in the Contributions from the Society for Research on Meteorites. It is, moreover, a magazine in which both professional astronomers and astronomically minded laymen are always confident of finding material of interest. It has succeeded admirably in fulfilling the vision of its founder, and every reader looks forward to its continued successful career.

DORRIT HOFFLEIT

VOL. II, No. 5 — MARCH, 1943
Whole Number 17

CONTENTS

COVER: Whipple's comet, contact reproduction of a 75-minute exposure with the 16-inch Metcalf refractor at Harvard's Oak Ridge station, February 2-3, 1943, by Henry Sawyer. (See page 22.)

BACK COVER: One of the well-known series of Lick Observatory photographs is of the full moon, taken by N. U. Mayall with the Crossley reflector.

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Our Nearest Cosmic Neighbors

By Armstrong Thomas, *Sproul Observatory*

In 1844, Bessel discovered that the course of Sirius is not a straight line, but that the star moves along a wavy path. He explained this behavior by assuming that this bright star must be revolving about some unknown body while traveling through space. His supposition proved correct, for 18 years later Alvan G. Clark, famous lens maker, actually saw this object, its light all but drowned out in the brilliance of the parent star.

Telescopes of long focal length, such as the Sproul refractor, are important for detecting and measuring small deviations in the positions of stars. These deviations give information regarding the state of motion of the galaxy and also—more significant for this discussion—they reveal the distance and orbital motion of double star systems. If we then study the light from a star by means of its spectrum, we may combine our data to determine the star's mass, luminosity, color, diameter, and density.

Suppose that we wish to study the stars in detail, and we proceed to select a representative group which may serve as a sample for the rest. The choice of sample stars is important, and there are a number of alternatives: we may choose the nearest stars, or the brightest stars, or a group at random. Large reflectors, because of their great light-gathering power, reach far out into space; but in going far out, we are defeating our purpose by selecting stars of a particular class—those intrinsically bright stars which appear on our photographic plates only because they are bright—and we miss those stars, intrinsically faint, which actually are in the majority. For our purpose, then, we shall consider the nearby stars, and arbitrarily set a distance limit at five parsecs, which is 16 light-years. In this small volume of the universe, astronomers have found 49 stars.

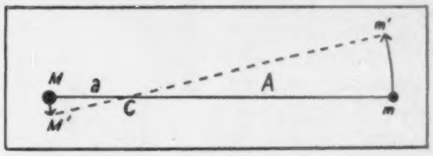
How do we know that these actually are the nearest stars? Or, to put it differently, how do we determine the distance of a star? Astronomers have no less than a dozen methods of determining stellar distances; but, for a nearby star, measuring its parallax is the most satisfactory method, and an accuracy of better than 95 per cent is attained. Parallax is the apparent displacement of an object due to a change in position of an observer. *Stellar parallax* is defined as the angle subtended by the radius of the earth's orbit as seen from the star. This seems rather a roundabout definition, but this same parallax appears in the form of a small ellipse which the star describes in the sky in consequence of the revolution of the earth around the sun once a year.

As an illustration, suppose that you are on a merry-go-round and observe a flagpole at a distance of, say, 100 feet. As you go around, the pole apparently has a motion back and forth against the more distant background. If the pole be nearer you, the displacement will be greater; if it be quite far away, the motion will be so small as to escape detection. Similarly, as the earth revolves about the sun, we may observe the change in position of a star against the "stationary" background of more distant stars, and this displacement is a measure of the star's distance. In actual practice, the problem is a delicate one; the displacement is but .01 mm. on the Sproul plates for a star 16 light-years distant, and many refinements must be introduced in the reductions.

But each parallax determination involves considerable labor. There are countless stars in the sky, and we cannot measure them all, so how do we choose? One might suggest that the brightest stars are most likely to be the nearest and proceed to select stars from such a list, but this will soon show us that apparent brightness is no criterion of distance; of the 22 brightest stars, for example, only four are nearer than 16 light-years. We must therefore look elsewhere for some indication of nearness.

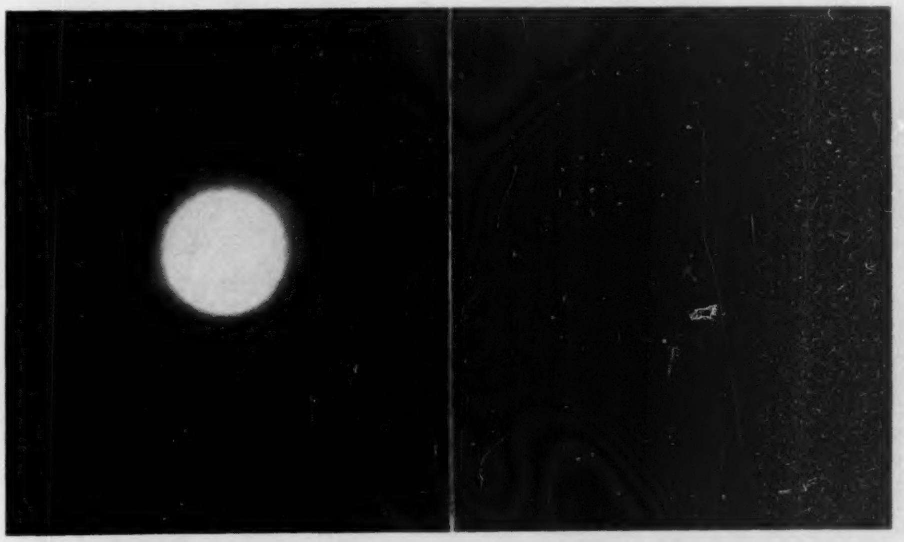
In this connection, consider a crowd of people in a busy market place. Persons near us appear to dart by quickly compared to those more distant, who seem to have relatively small motions. The stars, too, have random motions—their present configurations in familiar constellations will become distorted in the distant future. This cross motion of stars, termed *proper motion,* may readily be seen by comparing two telescopic photographs of a region taken a year or so apart. A few stars, of course, will be directed either toward or away from us and thus escape our notice; but in the great majority of cases the nearby stars exhibit a large proper motion, and it is from this category that the greater part of an observatory's parallax program is usually made.

Our 49 stars are not all isolated like the sun. Twenty five of them—a little more than half—are single stars, but 16 are members of double star systems, and six are members of triple star systems. Double stars are important, for they provide a means whereby we may directly determine stellar masses. Consider

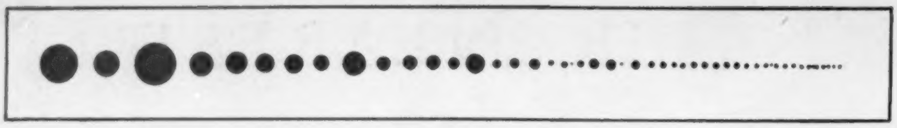


Stellar masses may be determined from binary star systems.

two stars of masses M and m, as shown in the diagram. If we could connect them by a weightless rod, they would balance at some point C, which we call the center of mass. We speak of the moon as revolving about the earth, but actually the earth and moon revolve about such a center of mass. Hence,



Two stars at about the same distance from us, but differing in real brightness 1,300,000 times, are Sirius (left) and Wolf 359 (arrow). These are contact prints of two Sproul photos, 2-hour exposures showing stars below 14th magnitude; Sirius, by the author; Wolf 359, by Roy W. Delaplaine; scale 1 mm. = 18″.87.



The circles show the relative sizes of the 49 nearest stars, and they are arranged in order of intrinsic brightness, from left to right.

when M moves to a position M', m moves to m', C retaining a position along the line connecting the two bodies. C moves in a straight line in space; M and m move in wavy lines. Our double star system is in equilibrium, so, where a and A are the distances of M and m from C, respectively, we have the simple relation,

$$Ma = mA. \qquad (1)$$

A and a are measured in seconds of arc, but may be converted to linear measure if we know the distance of the system from us. We have another relation, derived from Kepler's laws of motion:

$$M + m = (A + a)^3/P^2, \qquad (2)$$

where the masses are expressed in terms of the sun's mass, A and a are in terms of the distance earth-sun (the astronomical unit), and P is the period in years. (1) and (2) then will give the individual masses of the stars; (1) alone gives only the ratio of their masses. (We have no means for finding directly the mass of a star which is not a member of a double star system, but it can be estimated from what is known as the mass-luminosity relation. It has been found that if the stars of known mass are plotted against their intrinsic luminosities, a smooth curve results for the majority of them. Hence, if we know a star's luminosity, expressed as *absolute magnitude*, we may read its mass from the curve.)

In the table is given data on the nine nearest of our 49 stars. Note that the masses differ very little from the average, which is about that of the sun. But in other respects, we see that our stars differ greatly.

Sirius is more than a million times as luminous as Wolf 359; if the table included all stars of known luminosity, we would see that the range in this characteristic is a billionfold. Now arrange the 49 stars in order of intrinsic luminosity (as illustrated). In order, they are Sirius A, Altair, Procyon A, Alpha Centauri A, the sun, and so forth; Wolf 359 is last. This luminosity sequence is also a color sequence. The stars to the left are white or blue; by the time we get to the sun, they are yellow; thence orange, red-orange, and finally, red and deep red. We notice, too, that in this sequence these stars are arranged nearly in order of size—the bright blue stars are the largest, the red ones, the smallest. Notable exceptions are three small white stars, *white dwarfs*, which are out of order as to both color and size; mention of these will be made later.

We cannot treat all 49 sample stars individually here, but the nine nearest provide a rather good "sample of the sample," and we shall proceed briefly to discuss each in order.

The sun is in many respects just an average star. Like the others, it is a luminous gaseous body, radiating its energy into space. It is "burning up," but not in the usual sense where we associate burning with the combination of a substance with oxygen. By means of a series of atomic reactions, its mass is converted into energy; however, this mass is but slowly used up in the process.

The sun's light takes only eight minutes to reach us, so that it is quite near compared to our next nearest star, whose light takes over four years to reach the earth.

Alpha Centauri is a system consisting of three stars. A and B revolve about each other in a period of 80 years. C, relatively distant from A and B, takes a million years to complete its orbit about the close pair; it is known as Proxima, for it is perhaps our nearest star not counting the sun. (See "Our Nearest Stellar Neighbor," *Sky and Telescope*, November, 1942.) Alpha Centauri is third only to Sirius in apparent brightness, but the star is not visible from the latitude of New York.

Barnard's star, in the constellation of Ophiuchus, is invisible to the naked eye. It has the largest known proper motion. In one year it travels through an arc of 10 seconds, or in 180 years a distance equal to the apparent diameter of the moon. It is unlikely that any possible companion of Barnard's star will ever be seen, but if such a companion exists, it may eventually reveal itself through perturbations in the motion of the brighter star.

Wolf 359 holds next place in our list, but its position is shaky. The parallax of this star, determined from rather weak data, is very nearly the same as that of Lalande 21185, whose parallax is better established. It is expected that there will be forthcoming from Sproul Observatory in the next year or two an improved parallax solution which, we hope, will finally settle the matter. Wolf 359, incidentally, has the distinction of being intrinsically the faintest star known.

We mentioned Sirius earlier in this article. The companion of Sirius is a white dwarf, one of that group of stars which obstinately refuses to take its proper place on star diagrams and curves. The spectrum of the star gives its surface brightness; the total surface area and diameter follow therefrom. And then comes a startling observation: when the density is derived from the computed mass and radius, we find that a cubic inch of this star weighs a ton! It is difficult to conceive a density so great as this and we might conclude that an error had somewhere crept into our calculations. But fortunately we have a check from an entirely independent source. Light emanating through a strong gravitational field has its spectral lines shifted toward the red; this effect—known as the Einstein shift—is proportional to the mass of the body divided by its radius. Sirius and its white dwarf companion present a perfect case of the necessary initial conditions, and the results obtained therefrom are in excellent agreement with the observed data. The high density of white dwarfs is explained in that the atomic particles making up their mass are spaced much more closely than in matter familiar to us on earth.

Evidently, there is a wide variety of stars in our sample of the universe: single stars, double stars, and triple star systems; stars that vary greatly in mass, luminosity, color, size, and density. But in any kind of sampling, we must realize the limitations imposed because of our choice of selection. There are stars missing from our list, such as the red giant, Betelgeuse. This star has a density less than that in the ordinary thermos bottle vacuum, and its size compares with that of the orbit of Mars about the sun. But Betelgeuse is an example of stars that are comparatively rare; we see them from great distances only because of their brilliance.

Perhaps there are other stars fainter than those on our list, but if they are not found within our limit of 16 light-years, it is unlikely that they will be discovered at all. It seems reasonable to assume, then, that our nearby stars comprise a group which is as near a representative sample of all stars as we may hope to discover, and that further study of the nearby stars is an excellent move toward a better knowledge of the universe.

THE NINE NEAREST STARS

Name	*Distance (lt.-yrs.)*	*Parallax*	*Proper motion*	*Appar. mag.*	*Abs. mag.*	*Luminosity (sun = 1)*	*Mass (sun = 1)*	*Spectral class*
Sun	...	...	...	−26.7	+5	1	1	*G*0
α Centauri *A*	4.28	0″.761	3″.68	0.3	4.7	1.3	1.1	*G*4
α Centauri *B*	"	"	"	1.7	6.1	.36	0.9	*K*1
α Centauri *C*	"	"	3″.85	11	15.4	.000069	...	*M*
Barnard's star	6.05	0″.539	10 .30	9.7	13.4	.00044	...	*M*6
Wolf 359	8.0	.408	4 .84	13.5	16.6	.000023	...	*M*8
Lalande 21185	8.0	.406	4 .78	7.6	10.6	.0058	...	*M*2
Sirius *A*	8.6	0″.381	1 .32	−1.6	1.3	30.	2.2	*A*0
Sirius *B*	"	"	"	7.1	10.0	.010	1.0	*A*5

MARCH is the windy, "lion-and-lamb" spring month to most of us; but in the Arctic it is the last month of winter darkness and cold, and in the Southern Hemisphere it marks the beginning of autumn. The sun has just crossed the celestial equator from the southern to the northern half of the sky; its vertical rays are now spiraling northward day after day as the north pole of the earth is turned more and more toward the sun. We do not feel this northward advance of the sun on any particular day. There is no "line" storm; that is to say, there is no storm that is *caused* by the sun's crossing the equator (called "the line"). There are storms, it is true, about this time of year; and some of them are equal in intensity to those of midwinter. But they may come any time in March. Perhaps those in the last third of the month, near the equinox, stand out in contrast to the milder storms of middle and late spring, and thereby take on prominence and a certain association with the sun's crossing the equator.

Snow squalls at 10:47 a.m., March 13, 1936. Photo by the author at Blue Hill Observatory.

MARCH WEATHER

By Charles F. Brooks

Director, Harvard's Blue Hill Meteorological Observatory

What is the weather in March in those parts of the world featured in the news these days? The New Englander would say at once, paraphrasing Mark Twain, that all you need to know about the weather anywhere, you can find out by simply watching a day's weather go by here. If we stretch this "day" to the whole month, and consider the weather antics of all Marches of which we have record, we shall have to admit that New England, and the northeastern United States generally, can match March weather anywhere else in the world except in the inner tropics, the inner polar regions, and the high mountains. We may have temperatures in the 80's or below zero. The landscape may be turning green, or it may still be covered with a far-flung mantle of snow. The winds may play gently upon us, or they may tear through the bare trees and swirl the snow into great drifts. Tropical showers may fall; or there may be simply drizzle and fog. Ice storms not infrequently make slippery going, and bear or tear down the trees and wires, but when the sun shines, it is usually bright, though sometimes dimmed by dust from city streets or plowed fields.

This alternating mixture of subtropical and subpolar weather is not fortuitous, capricious though it may seem. It comes from the alternation of south and north winds with the passing low-pressure and high-pressure systems as they progress eastward in middle latitudes. A tropical air mass starting northward will, however, gradually lose some of its peculiarly distinctive qualities. As it suffers chilling by the surface, the relative humidity rises and the air loses some of its refinement. On the other hand, a polar air mass invading middle latitudes will be warmed by the ground and rendered turbulent, even showery, thereby. But these air masses come so fast at times that their modification by the underlying surface is surprisingly small. It is then that we can almost believe we have suddenly been transferred to the tropics or to the polar regions, as the case may be.

Let us review some of the average conditions in March in certain prominent cities of the world. For simplicity, I shall take only temperature and precipitation. The temperatures to be cited are the averages for day and night together. These are about the same as those at 10 a.m. local time. The average daily lowest and highest temperatures are five or 10 Fahrenheit degrees (three to five centigrade degrees) lower or higher.

The cold cities, between 17° and 25° F. (9° to 4° below zero C.) are, from colder to less cold: Archangel, on the Arctic coast of the U.S.S.R., Moscow, Leningrad, Montreal. Yes, Moscow, though 300 miles farther south, is slightly colder than Leningrad, which is on the coast. The moderately cold cities, only a few degrees under freezing, are: Vladivostok, Stykkisholm (in Iceland), and Kiev. Those up to a few degrees above freezing (not above 37° F., 3° C.) are: Chicago, Boston, Bergen, Berlin. Slightly warmer (up to 44° F., 7° C.) are: Sevastopol, Washington, Belgrade, and Tokyo. Above 50° F. (10° C.) are Tunis, Rome, Chungking, Los Angeles. Above 60° F. (16° C.), we find Valparaiso, Jacksonville, San Antonio, Bengasi, Suez. Above 68° F. (20° C.) come Sydney, Buenos Aires, Dakar. The cities that are really hot in March, averaging over 77° F. (25° C.), are Rio de Janeiro, Mandalay, Port Darwin. Port Darwin is 83° F. (28.5° C.), and it is only there that precipitation is particularly heavy, averaging 10 inches (260 mm.) in March, but this decreases to four inches (107 mm.) in April.

In the tropical southwestern South Pacific and southwestern South Indian Oceans, March is a month marked by hurricanes. These storms are fairly numerous in this autumn month all through the American approaches to Australia, and across the British route to India. But they are recognizable from a distance; their normal tracks are known, and by skillful navigation, the dangerous inner ring of their great whirls can be avoided. Presumably, there are weather maps being made (by secret code) which should keep at least the major storms spotted.

By April, these southern storms will be on the wane, as will also be the tropical rainfalls of the northern sector of Australia, with the southeast trade winds replacing the northwest monsoon. Then the wet tropics will be on the other side of the equator—the north side.

Taking a world view of the temperature change in spring, we find falling temperatures in the tropics south of the equator and rising temperatures north. A summary by Hann shows that at latitude 30° the greatest rate of change in temperature occurs in the second half of February; at latitude 40°, in the first half of March; at 50° and 60°, in the second half of March; at 70°, in the second half of April; and at latitude 80°, in the first half of May. Thus, in the northern half of the United States, in Canada, and throughout Europe (except in the extreme north), the second half of March is the time of greatest seasonal rise in temperature. At the same time, it is a month of great contrasts between the still snow-covered north and the blossoming south. Herein lies the basis for the changeableness of March weather, and for the remarkable contrasts between March of one year and March of another at the same place—contrasts related to the extent of the snow cover, which, however, is in itself an expression of the general unseasonableness of the weather.

So in March the Northern Hemisphere emerges from winter. At the same time, the Southern Hemisphere begins to leave summer behind. In both hemispheres, this month is one of stimulation.

AMERICAN ASTRONOMERS REPORT

By courtesy of the authors, the Editors present abstracts of some of the more popular papers given at the 69th meeting of the American Astronomical Society in December. Complete abstracts will appear in the Astronomical Journal *and elsewhere.*

Meteor Crater Meteorite

A METEORITE no larger than a small building or a big room may have packed sufficient punch to produce the famous Meteor Crater near Winslow, Ariz., according to a paper by Dr. C. C. Wylie, of the University of Iowa. His estimates were based on the amounts of nitroglycerin used in mines producing the largest craters in World War I, and from the size of the largest craters produced by blasts set off by oil companies.

The earlier estimates of the size of the meteorite which produced the crater, which is about 4,000 feet in diameter and 600 feet deep, were made from observations of stones dropped from a height into relatively soft earth. Some investigators placed the diameter as 3,000 feet, and the weight as over three billion tons.

Borings show that the rock is pulverized to a depth of 700 feet or more below the present bottom of the crater on the southwest, so the next estimates were made by those who had calculated that the pressures developed when the meteor struck must have been a hundred times that needed to crush rock and iron. If the meteor flattened out on striking, the assumed diameter could be even less. Opik assumed a diameter of 250 to 350 feet, and a weight of two million to five million tons. Making liberal estimates of the mechanical energy to produce the crater, however, Opik could account for only about one per cent of the kinetic energy which his big meteor would have; he made no attempt to explain what happened to the other 99 per cent.

Moulton, Spencer, and Dr. Wylie have argued that both theory and observation indicate that, as a crater-producing meteor is stopped by the rock it encounters, the energy is converted into heat. This heat vaporizes much of the rock encountered, and nearly all of the meteor, with explosive suddenness. The resulting explosion is equivalent to that of an amount of nitroglycerin whose heat of combustion is equal to the heat produced by the impact of the meteor.

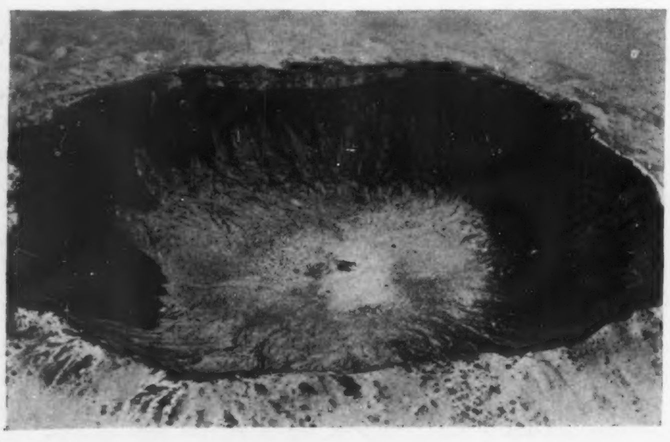
For various striking velocities, Dr. Wylie computed the radius of a spherical iron meteorite whose impact would cause such an explosion. Because of air resistance, the striking velocity of even such a large meteor is definitely less than the velocity with which it enters the atmosphere; this retardation was allowed for in his calculations.

Since large meteors have been found to move in direct orbits (in the same direction as the earth revolves around the sun), a velocity of from seven to 20 miles per second can be assumed for their entrance into the atmosphere. The results, for the diameter of the meteor required to produce Meteor Crater, are: velocity, seven miles per second, diameter 53 feet; 10 miles per second, 43 feet; 15 miles, 35 feet; 20 miles, 30 feet. For 15 miles per second, a reasonably probable figure, the weight comes out about 5,000 tons. If the resistance of the air had not been allowed for, the results would all have been smaller, for example: 25 feet instead of 35 feet for an entrance velocity of 15 miles per second, but, of course, the air resistance should be considered in these calculations.

Six-Color Photometry of Stars

THE continuation and extension of previous work with the photoelectric cell applied to precise measures of the colors of stars was presented by Drs. A. E. Whitford and Joel Stebbins, of Mt. Wilson and Washburn Observatories. By means of suitable glass filters six spectral regions are isolated, ranging from 3,500 angstroms in the ultraviolet to 10,300 angstroms in the infrared. The new colors give a scale for the so-called color index of a star about four times as great as the international scale, which is based upon the difference between photographic and visual brightness. In certain cases it is possible to determine the absolute or intrinsic brightness of a star, and hence its distance, simply by measures of its color. Another application of the method is the determination of the relative temperatures of the stars just as the metallurgist measures the temperatures of an incandescent piece of metal by matching its color against a known standard.

During the past 10 years the authors have devoted considerable effort to the study of the dust in interstellar spaces made evident by the reddening of the light of distant stars, just as the sun is apparently reddened near the horizon by the dust in the earth's atmosphere. The previous work has all been done in two colors, but the new method with six colors is much more delicate and powerful. In fact, some difficulty is experienced in finding stars of really normal color, those that we can be sure are unaffected by interstellar dust. It has been known that the clouds of dust are quite irregularly distributed in space, but the new observations give evidence that the quality of this dust—that is, the proportion of large and small particles—is much the same everywhere.



Meteor Crater presents problems to the astronomer, as well as holding a peculiar fascination for the layman. Airplane photo by Clyde Fisher.

Novae Spectra

DR. Dean B. McLaughlin, who shared with *Sky and Telescope* readers his early observations of Nova Puppis (see January issue), gave a paper on oscillatory changes in the spectra of novae. The majority of new stars decline from maximum light rather smoothly, but a fairly large minority show spasmodic secondary brightenings and fadings superimposed on the general decline. Dr. McLaughlin has studied the changes in spectra which accompany these secondary variations, using spectrograms taken at seven American observatories. He stated that, in general, a secondary brightening of a nova returns the spectrum to a type which closely resembles an earlier period of the nova's post-maximum history.

Emission in the Nuclei of Spiral Nebulae

SPIRAL nebulae are generally observed to give dark-line spectra of class *G*, the same as that of the sun. This is taken to indicate that a spiral's observed spectrum is really a composite of that of the millions of stars composing the sys-

tem, and in the case of many near-by spirals, these stars have been resolved into individuals by our largest telescopes. In the outer parts of some of these resolved spirals, bright diffuse nebulosities, comparable to the nebula in Orion in our own galaxy, have been observed. These nebulae, being clouds of diffuse and incandescent gas, have spectra containing bright emission lines instead of the dark-line spectra usual to stars.

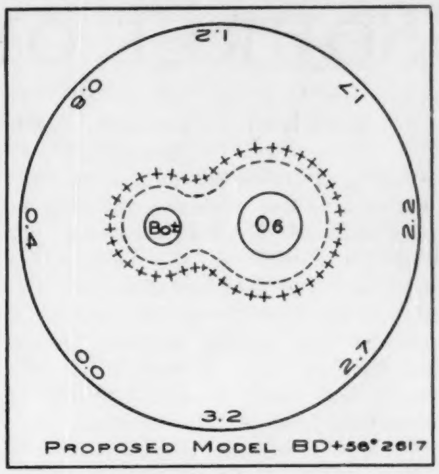
Dr. Carl K. Seyfert, of Warner and Swasey Observatory, has been studying six of a rare class of spirals whose nuclei exhibit high-excitation nebular emission lines superposed on the usual *G*-type absorption spectrum. He used spectrograms of relatively large dispersion obtained mostly with the 60-inch reflector at Mt. Wilson Observatory, and found two of the nuclei to have line intensities closely resembling those in the spectrum of the planetary nebula N.G.C. 7027. (See "'Ages of Observation,'" *Sky and Telescope*, August, 1942.)

Observations of the nuclear color temperatures gave values very close to 5,000° K. for all the spirals except one, in close agreement with photoelectric observations by Dr. Joel Stebbins for N.G.C. 1068. The lines in all the objects studied are widened, presumably by rapid motion of the material emitting the light—the total widths of the lines corresponding to speeds of from 1,000 kilometers per second to 8,500 kilometers per second. Such wide emission lines are not observed in the spectra of the brightest diffuse nebulae in the outer parts of other extragalactic nebulae. All of these observations are undoubtedly closely related with the at present undetermined composition of the nuclei of the spirals concerned, and further progress of Dr. Seyfert's investigations will be awaited with considerable interest.

Pre-fission Binary?

AMERICAN and Canadian astronomers together told the story of many stars which are known to be double only by periodic fluctuations in their light, or by variations of a similar nature in their spectra. Chief among these reports was one by Dr. W. Carl Rufus, director of the Observatory of the University of Michigan, on a star known as BD + 56° 2617 (A). Periodic changes in a cycle of 3.7 days in the appearance and relative intensities of some of its spectral lines, in addition to their displacements owing to the rotation of one part of the star around the other, provide a basis for assuming that this star may represent a pre-fission stage in the formation of a double star. The spectral class and spectral changes in the star suggest the possibility of an *O6* star with a *B0* companion not yet separated.

Dr. Rufus pointed out that the possibility of other models of star systems to explain the observed spectral behavior should be kept in mind, but that the existence of the hour-glass or pre-fission double star is in harmony with the widely accepted fission theory of the formation of binaries of short period. He said that the large number of binary systems, and the larger percentage of spectroscopic binaries than visual in stars of early spectral class, are established facts. The existence of some stars near the stage of separation into two parts seems quite probable in spectral class *Oe5*. Variable radial velocity seems to be a characteristic of that class.



The circle is labeled in fractions of the period in days.

Two More Binaries

DANIEL M. POPPER, of Yerkes Observatory, also reported on a spectroscopic binary of the hour-glass or Beta Lyrae type. It is the star RY Scuti, long known as a variable with a period of 11 days, and the range in velocity of some portions of its atmosphere which seem alternately to approach and recede from us is 500 kilometers per second. This is probably the result of the rapid rotation of the two parts of the star around each other. Surrounding these parts there is a shell of gas, not uncommon in such cases.

In a second paper, Mr. Popper told of the variable star SX Aurigae. It is a double star whose components take only 29 hours to encircle each other completely, even though they each have a diameter about five times that of the sun, or on the order of four million miles.

Central Line Intensities

IN another of the several papers from Yerkes Observatory, Dr. Otto Struve, the director, discussed the problem of the central intensities of lines in stellar spectra—his work having been carried on in recent months with the help of the large Coudé spectrograph at McDonald Observatory in Texas. A star spectrum obtained with this instrument is about 20 inches long and the dispersion is about two angstroms in the violet region for every millimeter on the plate.

An important feature of the spectra of the hotter stars, those of types *A* and *B*, is that their absorption lines appear gray, instead of white, on the black background of the continuous spectrum (negative plate). The lines are said to be shallow, instead of deep, as they are in the spectrum of the sun. They give the appearance of light having struck the photographic plate before or after the exposure, causing a uniform fog over the entire spectrum. This pre-fogging actually occurs in the atmosphere of the star itself. The explanation of its origin is one of the most difficult problems of theoretical astrophysics.

An interesting clue to the matter is offered by the fact that the absorption lines of some stellar shells, like that of Gamma Cassiopeiae in 1940, show deep lines which are apparently quite free of the pre-fogging. The outcome of the discussion to which this leads is that the reversing layer of a star is itself a radiant mass of gas whose emission lines coincide with the normal absorption lines and tend to neutralize them.

Dr. Struve's paper goes on to draw attention to some very remarkable results on central line intensities obtained in the spectrum of Betelgeuse some years ago by Dr. Lyman Spitzer, Jr., of Yale University. These results have been confirmed and extended. The radiating layer of Betelgeuse has the remarkable property that it tends to neutralize some lines, but not others—a feature which is now satisfactorily explained by the theory presented in the paper.

Four Solar-type Atmospheres

OF the seven papers on the program prepared by astronomers of the Dominion Astrophysical Observatory, Victoria, one by K. O. Wright was a report on the atmospheres of four solar-type stars, including the sun.

The three stars chosen for comparison with the sun were Procyon, which is considered a dwarf star of somewhat higher surface temperature than the sun; Sadr, the star at the center of the Northern Cross, and Marfak, the brightest star in Perseus, both stars like Procyon and the sun, but giants in comparison to them as far as total brightness and size are concerned. Dr. Wright's investigation has been carried on for the past five years, and consisted of a detailed study of the line intensities in the spectra of the four stars. Nearly the entire visible region was covered and the equivalent widths of over 600 lines in each star's spectrum were measured. The abundance of 20 elements in each atmosphere has been calculated. The values for the sun agree very well with those obtained by Russell in 1929, and the agreement from star to star confirms the belief that the composition of these stellar atmospheres is remarkably uniform. Of course, of all the elements studied, hydrogen is the most predominant.

PART II

THE MOON AS A SOURCE OF TEKTITES

By H. H. NININGER, *Colorado Museum of Natural History*

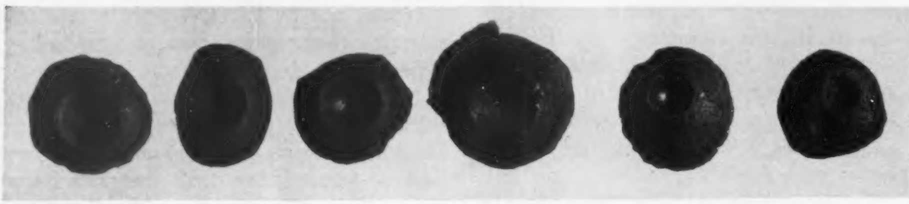
THE moon is 2,160 miles in diameter. It revolves around the earth at an average distance of about 238,000 miles. Its surface is extremely rough, the most important topographical features being high, steep mountains, extensive, smooth plains, and myriads of circular rimmed formations which have been termed craters. It is considered to be devoid of atmosphere and moisture. Due to the absence of these, the moon's surface experiences extremes of temperatures which take place with great suddenness, and which may be assumed to bring about rapid fragmentation of exposed rocks. Thermal and photometric studies indicate that the surface materials of the moon are very porous, or else are loosely piled, and that they are of a rather dark color.

Lunar gravity is only about one sixth as great at the moon's surface as is gravity at the surface of the earth. The average density of the substance of the moon expressed in terrestrial terms is about 3.4 as against 5.6 for the earth. This would mean that the outer mantle of the moon substance (which Fairchild has aptly termed lunite), weighed on a spring balance on the moon, would exert only about the same pull as does dry, white pine wood here on the earth. This extreme lightness coupled with the absence of any air resistance renders the lunite very sensitive to any mechanical force brought to bear upon it. A man wading rapidly through a mantle of lunite would send a spray of fragments to the front and to either side to a distance of several rods.

Whether or not we allow that the lunar craters were caused by meteorite impacts, we must assume that the moon's surface is and has been subjected to the same sort of cosmic bombardment as that experienced by our own planet, except that a meteorite strikes the lunar landscape with approximately the same velocity it would have at the outer fringe of our atmosphere. The full force of its momentum would have to be absorbed by the fluffy mantle of lunite into which it would readily sink to a great depth.

It is fair to assume that below the level penetrated by temperature changes and by meteorite blasting, the moon is a rigid body. If and when the invading meteorite reaches this level, it must come to a sudden halt. The sudden transformation of kinetic energy into heat results in a violent explosion reducing to gases much of the body's own mass and a certain amount of the surrounding materials. The explosion fractures certain of the lunite, fuses an additional quantity (the amount depending upon the violence and magnitude of the blast), and sends a violent charge of fragmental lunite in all directions.

Living as we do, accustomed to a heavy atmosphere, it is difficult for us to realize what would be the nature of such an explosion on the moon. The great Arizona meteorite, when it blasted the famous crater, threw large quantities of stone to distances of at least a mile and a half. Probably stray fragments were hurled much farther, although positive proof is difficult to produce after an interval of 20 to 50 thousand years. Our recent magnetic-rake survey discovered an abundant dispersal of small meteorite fragments to a radial distance of two and a half miles from the center of Meteor Crater, and larger meteorites were rather generously scattered to as far as seven or eight miles. Rock fragments also were probably thrown several miles, but being limestone they have dissolved; for a study of the crater walls indicated that a layer four to five inches thick has been removed by corrosion. This scattering was accomplished in spite of the tenacity of sediments cemented by hydration (of which there would be none in lunite), and against six times as much retardation from gravity as would be encountered on the moon. But the greatest factor operating to retard the flight of fragments from such an explosion on the earth is air resistance, which at high velocities becomes an insurmountable barrier, as the science of gunnery can well testify. In spite of air resistance, however, muzzle velocities of approximately 9,000 feet per second have been obtained experimentally. Without any obstructing atmosphere, velocities several times this figure might be realized, especially in materials of low specific gravity and inertia.



Some interesting australites—tektites from Australia.

Mathematicians assure us that the sudden stoppage of a mass of iron or stone traveling at even five miles per second would transform it into an explosive much more violent than those used in gunnery. The maximum velocity at which a meteorite may strike the moon's surface cannot be less than 45 miles per second. Surely this is more than sufficient to initiate in certain fragments of lunite a velocity greater than two miles per second, which is well above the velocity of escape from the moon.

Once a fragment escapes from the moon, it will either proceed into infinite space, or be gathered to the mother of that satellite, the earth. Naturally, the majority of meteorite impacts occur on the side of the moon away from our planet, because those meteors which are headed toward our side are in most cases diverted to the earth by its stronger gravitational influence. But there will be some landing near the perimeter of the moon's face which could send a spray of particles in our direction. Once such a spray has passed beyond the control of the moon and has come under the domination of the earth, the widely dispersed particles will begin to converge toward the center of the earth, so that when they arrive, not a whole hemisphere is sprinkled, but still a much larger area than is visited when a single meteorite disintegrates in the stratosphere and sprinkles its fragments over a few square miles.

The question arises as to why a succession of splashes from the moon should yield only glass which is so nearly uniform in composition as are tektites. Why should not explosions of meteorites send some fragments which are not materially different from the meteorites which are falling on the earth, at least as to chemical composition?

Such questions are definitely in order, and there are two possible approaches by which we may attempt a satisfactory answer. First, we must recognize the fact that showerings which may visit the earth not oftener than an average of once in 10,000 years would have given us no opportunity by direct observation to discover what these showers consist of. We can only infer, by a study of the materials we encounter in our environment, which are terrestrial and which are extraterrestrial. Meteor-

ites, which probably arrive somewhere on the planet every day, escaped the eye of science completely until the beginning of the 19th century. It may very well be that there are many different varieties of matter which owe their presence on our planet to the same force as that which gives us tektites, but which are, as yet, unrecognized. Any field man experienced in either geology or meteoritics well knows that there are a multitude of puzzling rock specimens whose presence cannot clearly be accounted for.

But there is another approach. The protracted, abundant blasting of the moon's surface which I have endeavored to depict in my recent paper, "Meteorites and the Moon," long ages ago reduced that surface to a deep mantle of fragments. Each new arrival sinks far into this mantle, where its enormous kinetic energy melts the meteorite itself and a portion of the fragmental lunite, allowing the heavier constituents to sink to a lower level, leaving the lighter materials at the surface of the melt. Thus, through millions of years, the lunar mantle has undergone a smelting process. Each cubic foot or meter of its surface layer has been melted a thousand times until only the lighter materials—mainly silica—are left at the surface, with, of course, a certain admixture of the meteoritic substances. The fact that nickel has been found in a few tektites would seem to bear out this idea. And it is by no means impossible that some rare forms of "meteorites" are in reality tektites.

It would be unwise to try to predict what may finally be the ramifications of this study of tektites when once it gets under way. At present, the majority of scientists are awaiting an introduction to the stranger. And it is amazing how the tempo of progress is stepped up when multitudes begin to contribute bits of information to a pool of knowledge which previously had represented the efforts of only a few.

I well remember how in the '20's I was painfully though unsuccessfully trying to convince the "authorities" that meteorites could be discovered by a planned search in the Great Plains. Enthusiastic though I was, I would have branded any man as a radical who would have predicted even half the success we have since attained in this search. I also remember when, a few years ago, it was demonstrated quite "clearly" before a meeting of the Society for Research on Meteorites that no tektites would ever be found in North America, because this continent lay outside the "great circles." Then, within a year after that meeting, hundreds of tektites were being collected in Texas.

Perhaps on some not-too-distant day, man may be permitted to witness the fall of a shower of tektites, and thus finally settle some of the questions regarding these interesting and puzzling objects. We must not, however, look forward to this too optimistically, because our own planet shields our side of the moon rather effectively. But when that absorbing event takes place, we shall be prepared, and not treat it with such skepticism as were treated the first witnessed meteorite falls.

NEWS NOTES

By Dorrit Hoffleit

S.S. GEORGE E. HALE

The memory of the foremost astrophysicist of the past generation has recently been honored in the naming of a victory ship, the S.S. *George E. Hale*, which was launched at 10 p.m., Tuesday, January 19th, by the California Shipbuilding Corporation. This is the 125th ship launched by this company in the present war production program. The keel was laid only 27 days previously. Mrs. G. E. Hale, the astronomer's widow, was the sponsor, and her daughter, Mrs. Paul A. Scherer, was the matron of honor at the launching.

George Ellery Hale was the inventor of the spectroheliograph (also invented independently by Deslandres), founder of the *Astrophysical Journal*, and the genius behind the construction of the Yerkes and Mt. Wilson Observatories with their world's largest refracting and reflecting telescopes. His latest great achievement was the practical conception of the 200-inch Palomar reflector. In 1936, a symposium in honor of his many achievements and services to astronomy was held at Harvard College Observatory. This has been recorded as "The Works of George Ellery Hale," in the July-December numbers of *The Telescope* of that year. Dr. Hale died on February 22, 1938, at 70 years.

Hale's significant services to astronomy began early—at the age of 20 he founded the Kenwood Observatory in Chicago. We trust that the S.S. *George E. Hale* will continue to live up to that spirit of service and devotion to a cause that its name signifies to every astronomer.

DOROTHEA K. ROBERTS

In October, 1942, a noted woman astronomer died in San Francisco at the age of 81. A native of California, she was educated in schools of Germany and France in years when American education could not compete with European. She was the first woman to receive the degree Docteur ès Sciences from the University of Paris. In 1887 an international committee adopted plans for the "wholesale" preparation of star charts and catalogues, the *Carte du Ciel*. Dr. Dorothea Klumpke was put in charge of the Bureau of Measurements, which agreed to chart all stars to the 14th magnitude and catalogue all to the 11th in a wide belt of the sky—an arduous, tremendous undertaking.

In 1901 she married the British amateur, Dr. Isaac Roberts, and from then until after his death, in 1904, she devoted her energies to his studies of the photography of nebulae and clusters. In commemoration of his birth she published, in 1929, the *Isaac Roberts Atlas of 52 Regions, a Guide to William Herschel's Fields*.

She received numerous honors, the most prized being her election as Chevalier de la Légion d'Honneur, receiving the Cross of the Legion from the President of France, in 1934. It was shortly thereafter that she returned to her native California.

RUSSIAN ASTRONOMY

At least one Russian observatory was still astronomically very active in 1942. A publication from the Abastumani Astrophysical Observatory on Mount Kanobili contains researches on such technical subjects as carbon isotopes in the spectra of *N*-type stars; colors of 1,758 stars near the galactic plane; color indices of 155 galactic nebulae; the chromospheres and photospheres of Cepheids; distributions of stars in the Milky Way; spectrohelioscopic and actinometric observations; photographic observations of asteroids; and the accurate latitude and longitude determination of the observatory. We hope 1943 will prove astronomically just as fruitful at that observatory.

SIMON MARIUS COMES INTO HIS OWN

A conflict on priorities has existed ever since the time of Galileo. Who first discovered the moons of Jupiter? Nearly everyone automatically answers, "Galileo." Yet Simon Marius, a German contemporary of Galileo's, laid claim to earlier observations, made in November, 1609, some months before Galileo's discovery. Ernst Zinner, noted historian of astronomy, has studied all the available evidence in detail, and concedes the priority of discovery to Marius.[1] Recognition of the importance of the discovery in displacing the earth from its supposed position at the center of the universe must, of course, still be granted to Galileo. But for Galileo's appreciation of the significance of the discovery, Marius' earlier observations might have remained unannounced.

[1] In an article in the *Vierteljahrschrift der Astronomischen Gesellschaft*, 1942, entitled "Zur Ehrenrettung des Simon Marius."

Plotting the Position

By Francis J. Heyden, S.J., *Harvard University*

In the January and February issues, we undertook the reduction of observations necessary to obtain a fix for the good ship Namedeleted; *the position is plotted here.*

THE two preceding articles on the "Use of the Nautical Almanac" and "Computing the Position" have given us all of the data we need for plotting the exact position of the S.S. *Namedeleted* on a Mercator chart. Before we set to work with pencil, dividers, and parallel rulers, let us put down the values we shall want to use. The solution for the 17-34-26 observation of the sun shows that we have an assumed position at 42° N and 65° 23′.9 W, an azimuth bearing of the sun of $Z_n = 276°.9$, and an intercept, $o - c = +15'.3$. Similarly, the solution for the moon's altitude was made for a dead-reckoning position (*DR*) at 42° 08′ N and 65° 36′ W, $Z_n = 132°$, intercept $-0'.2$. We must also remember that the ship is sailing due west, or a course of 270° true, at a speed of 20 knots. This is all we need to know before plotting the fix.

To recall a few notes from the article, "Elements of Celestial Navigation," in the September issue of *Sky and Telescope*, the observed altitudes determine lines of position. These are only small pieces of arc from large circles sweeping around the substellar point. Any point on one of the circles is a position at which the body would have the observed altitude. In plotting these lines on a chart, they are so short in contrast to the size of the whole circle that for practical purposes they can be represented by simple straight lines. Since the ship is somewhere on each observed line of position, the exact position or *fix* is where two or more such lines intersect.

To make our plot, we must first locate the position with respect to which we computed the values for bearing and intercept in each case, but this position is not necessarily that of our dead reckoning at the time of the observation. In the case of the S.S. *Namedeleted*, the observation of the moon was reduced (by Ageton) for the *DR* position, whereas that for the sun was reduced for an assumed position (*AP*) near the *DR* because Dreisonstok's method was used. This requires an assumed position such that the latitude equals a whole degree and the longitude is some value that makes the local hour angle a whole degree.

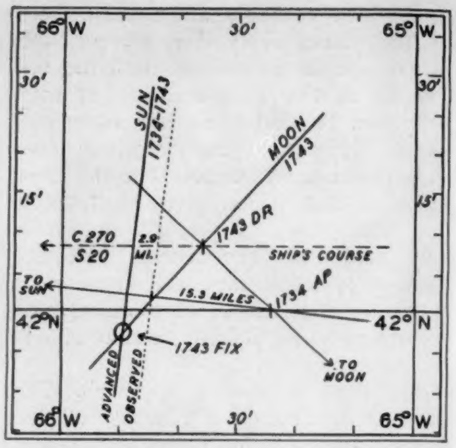
After plotting these positions of reference, and labeling them respectively *DR* and *AP* (adding, if desired, the corresponding times of observation), we draw straight lines through them in the directions given by the corresponding values of Z_n. In each case, it is sufficient to make the line long enough to extend about 20 nautical miles (20′) on either side of the position. This Z_n or azimuth line actually indicates the direction of the substellar point, and if extended far enough on a large enough chart, would pass through it. To avoid later confusion in laying off the intercept, an arrow may be drawn to indicate the direction of the observed object.

If $o - c$ is negative, it is laid off from the position *away* from the direction of the substellar point; if positive, it is laid off in the direction *toward* the substellar point. The actual length to measure is gotten from the latitude scale on the side of the chart, but we are careful to take the length from the latitude scale corresponding to the average latitude of the distance to be plotted or measured. At the place determined by the length of the intercept, the line of position is drawn perpendicular to the azimuth line.

To plot the fix in the present case, we may use an H.O. chart—No. 941, New York to Halifax—or, since we are far at sea and wish merely to know the position of the ship in latitude and longitude, a simple plotting sheet will suffice—even one we have drawn ourselves. If the chart has a compass rose, we can use that for laying off the azimuths; otherwise, we shall use a protractor. Parallel rulers are not absolutely essential, but no navigator would want to work long without them.

We decide to determine the fix for the time of the moon sight, 17-43. This sight was reduced by Ageton's method, so we locate and label on the chart the *DR* position of 42° 08′ N and 65° 36′ W. Through this point we draw a line with a bearing of 132°, and an arrow indicating the direction of the moon. The line of position lies just one fifth of a nautical mile away from the direction of the moon, and is drawn perpendicular to the 132° line. This is a smaller intercept than is usually met in practice, but, as we shall see, it does not indicate that the ship is actually near the *DR* position. Remember, the line of position must be at right angles to the azimuth line.

For the observation of the sun, we must be careful to draw the $Z_n = 276°.9$ line through the *AP* at 42° N, 65° 23′.9 W. Many a beginner working with a reduction by Dreisonstok's method goes astray by using the *DR* instead of the *AP*. This time the intercept of 15.3 nautical miles is *toward* the subsolar point; the line of position is dotted in the diagram.



The ship's course is a dashed line; the sun line of position before being advanced is dotted. It is merely coincidence that the azimuth line to the moon runs through the assumed position for the sun reduction.

If the ship were standing still between observations, the intersection of the two lines of position now drawn would mark the exact fix of the S.S. *Namedeleted*. However, the vessel is moving at a considerable speed—20 knots—on a course of 270°. We must take this into account and *advance the line of position* for the sun to where it would be at 17-43. To do this we first represent the ship's course by a line drawn in the direction of 270° through the *DR* for 17-43. Since the ship traveled at 20 knots for $8^m\ 41^s$, it must have moved westward a distance of 2.9 miles between the two observations. Hence, we transfer the sun line of position 2.9 miles to the westward. In practice, we open our dividers to this distance on the latitude scale on the side of the chart and then set off the 2.9 miles along the course line *from the point where the original line of position (dotted) intersects it.* At the new point we draw the advanced line of position parallel to the dotted one. This is the line of position for 17-43 for the sun, and its intersection with the moon's line of position for that same time indicates the true fix.

Our fix is at 41° 57′ N and 65° 49′ W. We see at once that the S.S. *Namedeleted* is about 14 miles and bearing 220° from the estimated *DR*. In mid-ocean such an error might not be serious, but near shore it would be dangerous. If the dead reckoning has been done very carefully without regard to wind or current, the captain would conclude that a combination of wind and current was responsible and he would try to make some allowance for them in his further dead reckoning.

Two views of the device described in this article. At left it is arranged to show world-wide time and star positions; at right it is mounted in a horizon ring for use at any desired place on the earth's surface.

A Model Planetarium

By V. C. Jones, *Winnipeg Centre, R.A.S.C.*

THIS simple planetarium tells what time it is in any part of the world and shows the location of principal astronomical objects in three systems of co-ordinates simultaneously.

It consists essentially of a globe representing the earth, with an equatorial hour ring which rotates in a left-to-right direction once in 24 hours. The ring is divided into hours and minutes. Half of the ring is shaded to indicate the hemisphere of darkness. A sun symbol is at the number 12. The planetarium is adjusted for latitude, longitude, and direction. Its axis then points to the north celestial pole, giving it an equatorial mounting as used on telescopes and in projection planetariums.

The globe stands still relative to the earth, and therefore turns with the earth while the sun symbol and hour ring actually stand still relative to the sun. The sun symbol points directly at the real sun in the sky continuously, thus telling where the local time is 12:00 noon. Similarly, the hour ring tells the local time at any place because local time is as shown for the meridian passing through that place. The planetarium becomes, therefore, a kind of natural clock. Arrows on the globe indicate standard zone time, or non-standard zone time as for Newfoundland.

A moon symbol is connected through gears which cause the symbol to fall back in relation to the hour ring, losing one revolution in 29½ days. It therefore truly represents the moon, and as it falls back its age and phase are automatically shown by small figures on the hour ring.

The hour ring carries a transparent celestial sphere on which are marked the visible stars. There are lines on it to represent the ecliptic, equator, declination circles, and hour circles, the last numbered to indicate right ascension and sidereal hour angle. On the ecliptic are shown the signs of the zodiac and the location of the sun for every day of the year. There are movable designations placed on the ecliptic to indicate planets. The celestial sphere is set by turning it until the sun symbol, which is adjustable for declination, is at the proper location for that day. It automatically maintains its correct position thereafter. By an arrangement of gears, the celestial sphere travels 1/365 of a rotation farther than the hour ring each day, giving the correct sidereal time at any place.

One is usually more interested in his own visible half of the heavens than in the other half. When placed in a case which hides the lower half of the globe, the planetarium presents to view only the half of the sky visible at the location for which it is set. The case has on it a horizon which is graduated to show azimuth, or angular distance from the north point. One can read directly the altitude and azimuth of any star, and its *geographical position* for the instant in question, provided the star's right ascension and declination are known. Also, a star location can be instantly transferred from any one of the three systems of co-ordinates to either of the other two—no mathematics is required. By this means, many questions of astronomy, surveying, and navigation by star sights are automatically solved. This will probably be of value to students of all ages and interests.

The horizon case further enables determination of the rising, transit, and setting times of the stars, planets, and other celestial bodies; also, the duration of sunlight and dark, of moonlight, and so on. Similar facts for any other time and place can be obtained by adjusting the globe to the latitude and time of that place.

Air force navigators should find the model planetarium useful in learning celestial navigation. For their purposes, the planetarium shows sidereal hour angle in degrees westward from the vernal equinox. This being in the same sense as west longitude makes it easier to establish one's position in the Western Hemisphere than by using right ascension in hours eastward.

Editor's Note: Readers wishing further details on the construction of this useful device may communicate with the author at 109 Lanark St., Winnipeg, Manitoba, Canada.

STARS IN SONG

BY WILLIAM H. BAR

Throughout the development of music, art a
bodies have received considerable attention
conceptions of their nature, as told here and in

The moon, three days old. Photo by R. G. Stephens.

ASTRONOMY has served many people in many ways. Long before it was formally considered a science, sky gazing told time, marked the seasons, indicated the weather, governed the physician, told farmers when to plant, prognosticated the future, guided the mariner, and in other ways touched the people's conduct whether they were aware of it or not. And down through the ages it has been the source of inspiration to those who follow the arts.

The Bible has many very ancient references to the sky. Some of them are rather vague and difficult to interpret—the dial of Ahaz on which the shadow moved backward, Joshua making the sun stand still, and references to various stars and constellations. "Canst thou bind the sweet influences of Pleiades?" Many connect this with the heliacal rising of this cluster of stars early in April. That is, it was a sign of spring, perhaps the cause of spring in the minds of these primitive people. Other interpretations give an entirely different meaning to the whole passage.

Perhaps the best known, and considered by many to be the most beautiful, passage is in the Psalm of David, "The heavens declare the glory of God; and the firmament sheweth his handiwork. Day unto day uttereth speech, and night unto night sheweth knowledge. There is no speech nor language, where their voice is not heard."

The moon has been the source of many beautiful lines and music in all its varieties—and the source of not a few errors.

The changing phases of the moon, one of the most obvious of all astronomical phenomena, has given rise to the belief that the moon is the source of fickleness.

O, swear not by the moon, the inconstant moon,
That monthly changes in her circled orb, . . .

Most people know that the word *lunatic* is derived directly from the Latin for moon, *luna*, and can mean moon-struck.

Many people suddenly discover one of those occasions when the sun and moon may be seen at the same time in the daytime sky, and report their observation as something quite unusual. Of course, it is not, but Lewis Carroll says:

The moon was shining sulkily
Because she thought the sun
Had got no business to be there
After the day was done—
"It's very rude of him," she said,
"To come and spoil the fun."

Within a few days after new moon you may have seen the "dark" part of the moon's disk faintly lighted by a pale light. This is earthshine—sunlight reflected from the earth to the moon and back again to the earth. This is known to some as "the old moon in the new moon's arms," and may be thought of as a sign of bad weather. In the ballad of *Sir Patrick Spens* we find:

I saw the new moon late yestreen
Wi' the auld moon in her arm.
And if we gang to sea, master,
I fear we'll come to harm.

The story of Abraham Lincoln's saving a defendant in a murder trial is an old one. A witness had said that the moon had just disappeared behind a cloud, but Lincoln with the almanac as his authority showed that there had been no moon at all that night.

Coleridge's "hornèd Moon, with one bright star within the nether tip," is about the most famous error. The moon is only a quarter million miles away and the nearest star is about 26 trillion miles away. But E. A. Powell in *Free Lance* performs the same astronomical feat. Rider Haggard in *King Solomon's Mines* places the *waning* moon in the early evening sky, where only a waxing moon should be. The waning moon belongs in the morning sky. Gene Stratton Porter gets the young crescent moon in the western evening sky in her *Harvester*, but later on the same night it rises above the trees and floods the country with light. A young crescent moon must set before midnight and does not come up again until the next day is well under way.

The writer saw many years ago a newspaper account of a lunar eclipse in which the reporter spoke of the beauty of the eclipse. But he closed by saying how fortunate it was that the moon was full that night. An eclipse, of course, can occur only close to the time of the full moon, as the earth must be in line with the sun and moon to cast its shadow on the moon.

Eclipses have been the source of a great many stories. No doubt eclipses are meant by some of the "darknesses" in the Bible. Mark Twain's, in *The Connecticut Yankee,* is the most famous eclipse that never happened. There was no eclipse on June 21, 528, according to Oppolzer's *Canon of Eclipses,* but the Connecticut Yankee, finding himself carried backward in time to King Arthur's Court, found in his notebook a handy memo about the eclipse. The time coincided exactly with his burning at the stake. His foreknowledge saved him and so impressed the Court that he was made "the Boss."

The yarn is no doubt based on a similar incident told about Columbus. This eclipse of the moon, however, did occur on February 29, 1504.

The longest possible eclipse of the sun lasts about 7½ minutes, but Rider Hag-

The central regions of the Milky Way.

G AND STORY

I. BARTON, JR.

sic, art and literature, the celestial ttention — often based on erroneous ere and in the Hayden Planetarium.

"Orion and Sycamore," a painting by D. Owen Stephens.

gard tells how a party of white men eluded the savages by taking advantage of the darkness caused by a solar eclipse that lasted "for more than an hour." And what is more remarkable, the moon was full that same night! Solar eclipses can occur only at new moon when the sun and moon are in line on the same side of the earth. And full moon comes some two weeks later.

The Milky Way, the great white way to the Indians' Happy Hunting Ground, is, according to an old French legend, the glimmering of lights held by angels to guide mortals on their way to heaven.

Galileo, in 1610, discovered the real nature of this band of light across the sky, and yet we find in Dryden's translation from Ovid this reference:

A way there is in heaven's expanded plain,
Which, when the skies are clear is seen below,
And mortals by the name of Milky know
The ground-work is of stars, through which the road
Lies open to the Thunderer's abode.

The telescope reveals the starry composition of the Milky Way and only by means of this instrument have we learned its true nature.

Everybody knows from childhood:
Twinkle, twinkle little star
How I wonder what you are,
Up above the world so high
Like a diamond in the sky.

Even the astronomer wonders "what you are," and a great deal of his work is devoted to finding out.

Comets come in for a fair number of literary references, mostly dealing with the superstition that they are forerunners of disaster. Shakespeare seemed to go in for comets in a big way:

In the most high and palmy state of Rome,
A little ere the mightiest Julius fell,
The graves stood tenantless, and the sheeted dead
Did squeak and gibber in the Roman streets:
As, stars with trains of fire and dews of blood,
Disasters in the sun; and the moist star,
Upon whose influence Neptune's empire stands,
Was sick almost to doomsday with eclipse.

In the above passage we find not only comets (or possibly meteors), but quite a few other astronomical references, perhaps a little obscure in places. But in *Julius Caesar* we find:

When beggars die, there are no comets seen;
The heavens themselves blaze forth the death of princes.

and elsewhere:

Comets, importing change of times and states,
Brandish your crystal tresses in the sky,
And with them scourge the bad revolting stars
That have consented unto Henry's death.

The two great poems of ancient times, while rather poor as poetry in most translations, are famous for describing the constellations. Aratos, the Greek astronomical poet who lived about 270 B.C., wrote a long poem on foretelling the weather by means of astronomical observations. For instance, by observing the cluster Praesepe (the Manger) in Cancer and the two stars flanking this open cluster, it was supposed a great deal could be learned about the weather to come.

Gaius Manilius, a Latin poet of the 1st century A.D., who wrote *Poeticon Astronomicon*, was probably the first Latin author to write extensively on astronomy. He followed Aratos closely in his constellation arrangement. The present text is from a manuscript exhumed in the 15th century from an old German library by Poggius, who rescued a great deal of our classical literature.

Now near the Twins behold Orion rise,
His arms extended measure half the skies;
His stride no less. Onward with steady face
He treads the boundless realm of starry space,
On each broad shoulder a bright gem displayed
While three obliquely grace his mighty blade.

And so one might run through Milton, Tennyson, and Bryant; Homer, Hesiod, and Whitman. There is no end to the number of times the sky has inspired the poet. We find a reference even to an almost impossible subject. Kipling, in his *Just So Stories*, mentions the precession of the equinoxes:

"One fine morning in the middle of the Precession of the Equinoxes . . . . And that very next morning, when there was nothing left of the Equinoxes because the Precession had preceded according to precedent, . . ."

BEGINNER'S PAGE

By Percy W. Witherell

Variable Stars—I

And the love
I told beneath the evening influence
Shall be as constant as its gentle star.
Nathaniel Parker Willis

Fortunately for the poet, the object of his affections was not as well informed as Juliet when she protested,

O, swear not by the moon, the inconstant moon,
That monthly changes in her circled orb,
Lest that thy love prove likewise variable.

Although Tycho saw a nova in 1572, the first observation of a typical variable star was of Omicron (o) Ceti, when in 1596 Fabricius listed a star that did not appear on previous charts. Bayer listed it again in 1603. It was not until 1638, however, that it was recorded that sometimes the star was visible and at other times invisible. Holwarda made this sensational discovery, when he noticed that Mira varied through five magnitudes, or 100 times in brightness. The 11-month period was established in 1660.

The next discovery was that Beta (β) Persei, known to the Arabs as Algol, the Demon Star, faded for several hours on every third night. A century passed before the mystery of Algol's light fluctuations was cleared up by the theory that this was a binary system of two stars rotating about a common center of gravity, which caused a periodic stellar eclipse.

Two more variables like Mira were the next to be found. Chi (χ) Cygni, with a period of 13⅓ months, was discovered by Kirch in 1686, and R Hydrae, period, 17 months, was found to be variable by Miraldi in 1704. The first varies 10 magnitudes, or 10,000 times in brightness; the period of the latter star has shortened three months since its discovery.

Near the end of the 18th century, another long-period variable like Mira was found, R Leonis, in 1780, and an eclipsing binary like Algol, Beta (β) Lyrae.

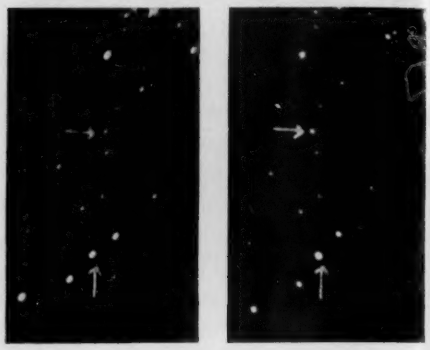
A new class of variables was next observed—stars with a period of less than a week and a change of a little less than one magnitude. The first was Delta (δ) Cephei with a period of five days, and the second, Eta (η) Aquilae which completed its cycle in seven days. This was the beginning of the list of Cepheids, which stars are so useful in the determination of distances, and which have so enlarged our conception of the distances of other galaxies.

Three more classes were begun when in 1795 Sir William Herschel noted the small, irregular fluctuations of Alpha (α) Herculis, and when R Coronae Borealis, with its peculiar changes, and R Scuti, with semi-regular periodicity, were added to the list.

At the beginning of the 19th century, 16 variables were on record: four long-period Mira-type stars, two Algol eclipsing variables, two Cepheids, one irregular, one peculiar, and one semi-regular variable, and five novae. After U Geminorum was found (of a class later known as the SS Cygni-type stars), the visual discovery of new types practically ceased. It is worthy of note that these early naked-eye variables have been and are today the object of thousands of painstaking observations, and their light curves are given the most careful study.

Groups of enthusiastic amateurs were formed to observe the light variations of these inconstant stars. When memberships became world wide, someone was on watch all the time to "spot" any changes in brightness. Two of the largest organizations are the British and American Associations of Variable Star Observers. The American Association has turned in to its recorder over 800,000 observations. One of the most notable sets is the more than 50,000 observations of SS Cygni made over a period of 46 years.

With the fainter stars recorded by photographic plates, the convenience of studying many stars on one plate in comparison with a plate of the same region taken at some previous time, and the improved optical methods of detecting light changes, the number of recorded variables has increased by leaps and bounds. By the end of the 19th century, the number of known variables was over a thousand. This total has since jumped to about 20,000.



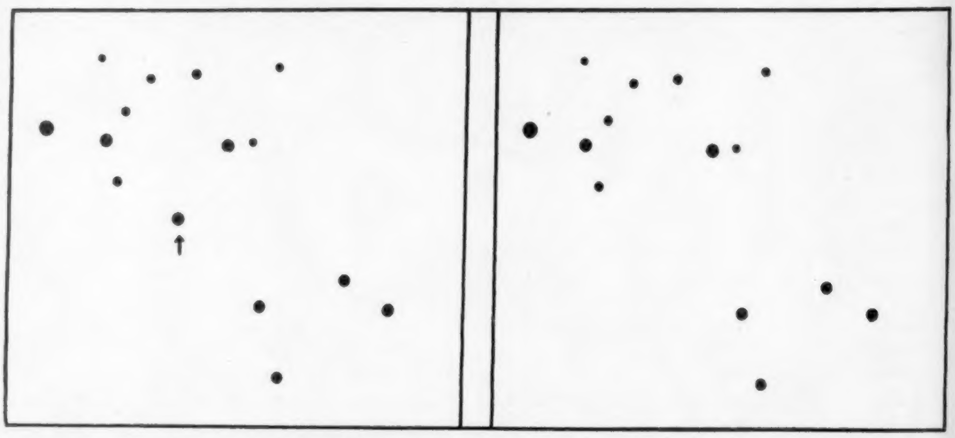
The variation of two Cepheids in Carina: VY (upper) has a period of 19 days; SX (lower), 4.86 days.

One convenient method which has resulted in the discovery of hundreds of variables is to superimpose a positive and a negative plate of the same region taken by the same camera at different times. The black dots on the negative show up on the white spots of the positive. It is very easy to detect when one of a pair is absent; it is evident that the star was not of the same brightness on the two dates of the exposures.

Another efficient machine is the blink microscope, in which each plate is alternately and rapidly flashed into the field of view. Any variation in the intensity of the two images produces a flash as the brighter image replaces the fainter one.

Stereoscopic projection of the images from two plates into the binocular microscope, which quickly shows an unsymmetrical arrangement, is another way of detecting variable stars.

Binary eclipsing variables are conveniently observed by taking multiple images on the same plate. This can be done by moving the telescope or the plateholder slightly in declination between successive exposures. Any variation of brightness is easily seen as a change in the size of the image on the plate.



When near its maximum brightness, Mira makes Cetus look as shown at the left, whereas near minimum the variable is not visible to the naked eye (right).

EDITORIAL CORRECTION

On page 9 of the February issue, in the table and in the sentence below the table, the period of Venus is erroneously given as 265 days. This figure should be 225 days. Also, the distance of Saturn in astronomical units is 9.539, not 9.529.

BOOKS AND THE SKY

OPTICS AND SERVICE INSTRUMENTS

Chemical Publishing Co., New York, 1941. 128 pages. $1.75.

THIS is a reprint of the book, *Elementary Notes on Optics and Their Application to Service Instruments,* published for the College of Military Science, England, in 1927, revised in 1941. The abbreviated title gives an incorrect impression, for there is no description of military optical instruments—the binocular is the only instrument described.

The principal advantage of the book is that it presents, in a small compass, the elementary optical principles made use of in common instruments, without making it necessary to search for this information in much larger volumes devoted principally to physics or to the more mathematical phases of optics. There are many good diagrams, and many simple demonstrations are explained. There is an excellent, though brief, section on the testing and adjustment of optical instruments.

Much important material, however, has been omitted. There is no mention of four of the six primary aberrations; nothing on the applications of prisms and lenses to instruments. There are a few glaring errors in the book, and, on the whole, its style is poor. The reviewer's impression is that there are many men in this country who could write a much better book in a few days' time.

CPL. EARLE B. BROWN
U. S. Army, Ordnance Dept.
Camp Santa Anita, Arcadia, Calif.

MAN AND HIS PHYSICAL WORLD

DWIGHT E. GRAY. D. Van Nostrand Co., Inc., New York, 1942. 665 pages. $3.75.

THIS book gives a survey of the fields of astronomy, chemistry, geology, and physics, at college level.

Prof. Gray has handled his subjects in such a way that each is discussed from the beginning, and a continuous story is told in which each division of the subject flows logically and naturally from the preceding one. By means of this systematic approach, the student is spared the feeling that he is being overwhelmed by an avalanche of seemingly unrelated scientific facts. Fundamental principles have been given precedence over new developments whenever space limitations prevented both from being treated in detail. The book maintains a close liaison between its subject matter and everyday experience and knowledge.

The approach is that of the scientific method, which points the way to objective observation and experiment in the solution of problems relating to phenomena of nature. The author gives the steps constituting the scientific method: 1. The recognition of the problem. 2. Collection of experimental facts or data. 3. Analysis of data and setting up of a tentative hypothesis. 4. Performance of test experiments. 5. Substantiation, modification, or abandonment of the hypothesis in the light of the results of the test experiments.

An interesting feature of the book is the inclusion at the end of each chapter of a liberal number of three types of questions: discussion questions, multiple choice questions, and true-false exercises. The last two are based entirely on the textbook and may be used for grade-determining quizzes. This reviewer found some of these quite entertaining, for example: "A scientific theory may be said to be entirely satisfactory if, (a) it accounts for over half the observed experimental facts, (b) it seems to be based on common sense, (c) almost everybody agrees with it, (d) more than half of the leading scientists in the field accept it, (e) it accounts for every bit of the experimental known at the time."

The author starts off the true-false tests with a choice one, to wit: "Science may be said to teach man how he can safely violate the laws of nature."

The exterior of the volume is attractive in two shades of blue. The book's 665 pages somehow manage to weigh slightly over three pounds. By an unfortunate accident, the first word that one meets at the top of the frontispiece is misspelled, but the rest of the work seems to be remarkably free from errors. There is a good index, and also a reading list of over 100 books and articles, with a reference to the chapters for which each is appropriate.

ROYAL M. FRYE
Boston University

NEW BOOKS RECEIVED

A START IN METEOROLOGY, *Armand N. Spitz.* 1942, *Henley.* 95 pp. $1.50.
This small book is designed to introduce young people interested in aviation to the science of weather forecasting. Questions and answers are included.

AIR NAVIGATION FOR BEGINNERS, *Scott G. Lamb.* 1942, *Henley.* 163 pp. $1.50.
In the same series as *A Start in Meteorology,* this book provides an introduction to air navigation for "those boys and girls who scan the skies today with the hope of soaring through the heavens tomorrow. . . ."

JULES VERNE—The Biography of an Imagination, *George H. Waltz, Jr.* 1943, *Henry Holt.* 223 pp. $2.50.
The story of the life and influence of a famous popularizer of science and "pioneer in a new school of writing."

WEATHER, *W. G. Kendrew.* 1943, *Oxford University Press.* 96 pp. $1.00.
A small book with a number of illustrations provides an easily assimilated introduction to the science of meteorology.

THE REVOLVING HEAVENS, *Reginald L. Waterfield.* 1942, *Duckworth,* London. 206 pages. 8 shillings, sixpence.
An elementary book explains why and how celestial phenomena happen, and is designed for the layman with a newly-acquired interest in the sky. The solar system is well covered, but comparatively little space is devoted to the sidereal universe.

Amateur Astronomers

THE SAGA OF NICK'S SCHMIDT

By Louis E. Bier

THE truth of the old adage, "Where there's a will there's a way," has been demonstrated time and again, and to amateur astronomers in the Pittsburgh district who are friends of Nicholas J. Waitkus, this truth has once more been emphasized by the fact that he has completed the construction of a Schmidt camera. Mr. Waitkus, almost invariably called Nick by his friends, is a printer by trade and does not lay claim to a formal schooling in the intricacies of mathematics and physics which many consider indispensable to the construction of the complicated Schmidt.

Thus, some of us were prone to be skeptical during the months of grinding, polishing, and figuring of the 12½-inch mirror and the formidable correcting lens. But seeing is believing, as we learned during the completion of the optical parts as well as during the development of the mounting, of the clock drive, and of the shutter and film holder mechanisms. It was evident that Nick would have little serious difficulty in joining the ever-growing ranks of amateur astronomers who have made satisfactory Schmidt cameras.

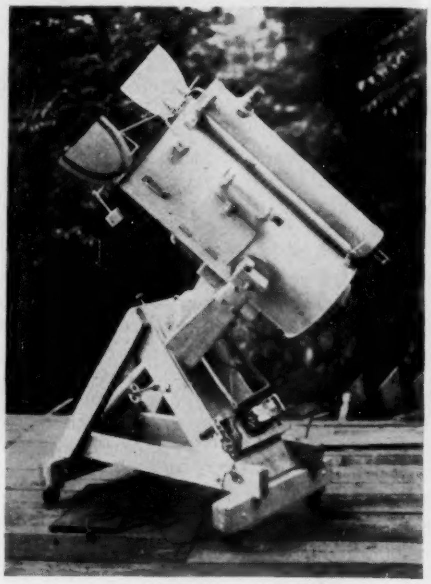
Nicholas J. Waitkus, his 6-inch reflector, and his camera mounted on a tree stump.

Mr. Waitkus has been an ardent amateur astronomer for a number of years; his first project was the old trusty of most pursuers of the hobby—a 6-inch reflecting telescope. From it he derived many hours of pleasure, scanning the infinity of space beyond the reach of unaided human vision, and becoming more and more familiar with members of the celestial host. In one project, he faithfully carried out an assignment in nova patrol for the one-time A.A.A.A. of Milwaukee.

It was not long before Mr. Waitkus, adept as a mechanic, began contriving apparatus for photographing the new friends he had made. His first venture along this line was a camera consisting of a 2-inch reading glass, a cigar box, and a 98c alarm clock. The clock was not, as might be suspected, for the purpose of awakening Nick—that was unnecessary—but it was to furnish motive power for the drive of the camera. The instrument worked surprisingly well, and, in referring to this early brain-child, Nick always displays an obvious paternal affection.

The first camera, however, was not the ultimate of his desires, so when a friend presented him with a 3-inch f/4 portrait lens and the admonition, "See what you can do with this," Nick readily accepted the challenge and set about making a better camera than the cigar-box type. It proved worthy, with a far better drive and much smoother bearings. While thinking about the type of base for this camera, his eyes happened to come to rest on a tree growing at the rear of his home. It was not long until, with saw in hand, he brought to an abrupt end the life of the familiar tree—a martyr to science. And the converted stump served well. With this instrument, 303 exposures were made.

In reading laudatory accounts of the performances of several Schmidt cameras made by other amateurs, Nick developed a hankering for one of his own. After turning the matter over in his mind, considering the complications of the construction of a Schmidt, he finally determined at least to try his hand at it. Work on the camera had not gone far before it became what might almost be considered a co-operative affair. Many of Nick's friends became intensely interested in the progress of the venture, and were eager to help. One, a retired engineer, stood ready to make drawings and to give advice when the builder found himself in doubt about a detail. Another gladly offered anything that was of use among his store of odds and ends that had been accumulated in his workshop over the years he had devoted to the hobby of astronomy. Still others were of assistance in many ways, including the giving of inspiration and encouragement, and for all these favors Nick is fervently grateful. Even luck is claimed to have been on his side in some instances, as, for example, when he was fortunate enough to have had the large yoke cast just a day or two before the government ordered the freezing of iron and steel.



The new Schmidt with guiding and finder telescopes, also guiding adjustment on left side of the motor.

Originally, the base was to have been of steel angle iron, but as an alternative Nick devised a victory base, as he called it, consisting of several pieces of 2x4 lumber and plenty of carriage bolts. It fulfills the requirements as well as is desired.

The back yard of the Waitkus residence is quite a steep grade, as are so many yards in the Pittsburgh region. The rear porch, several feet above the ground, was decided on as the most likely place to set up the massive instrument, weighing a total of 378 pounds. Obviously the porch was not nearly solid enough, so Nick cut a hole in the porch floor and built a pier on the ground beneath, thus providing a perfectly substantial foundation exactly where it was wanted.

The Waitkus Schmidt camera, of which construction details may be found in the "Gleanings" department of this issue, is now complete and ready to be put to work. Its owner intends some really serious use of the instrument, and we are all hoping for the discovery of Comet Waitkus, at least. However, Nick's favorite field is variable stars. He has expressed a desire for correspondence with owners of similar instruments—what they are doing and what their experiences have been would be of intense interest to him.

AMATEUR ASTRONOMERS ASSOCIATION

New York City

On March 3rd, *Four Years' Study of the Aurora Borealis* will be discussed by Dr. C. W. Gartlein, Cornell University. Dr. Peter van de Kamp, of Sproul Observatory, will speak on *Multiple Stars*, on March 17th. These lectures, held at the American Museum of Natural History, at 8:15 p.m., are open to the public.

ASTRONOMICAL ANECDOTES

BANISHMENT OF BUNK ABOUT BAYER

IN a most excellent publication, *Splendors of the Sky,* compiled by the editors of this journal, there is repeated a popular misconception in the statement that Albrecht Dürer made the beautiful copper engravings for the *Uranometria* of Bayer, the first of the many editions of which was published in 1603. Leaving aside the fact that in the book itself it is stated that the 51 plates were engraved by Alexander Mair, we may very easily dispose of Dürer's connection with the work by discovering that he died in 1528, more than 40 years before Bayer was born.

As given in Basil Brown's *Astronomical Atlases, Maps, and Charts,* the essential facts of the life of Johann Bayr (as his family preferred to spell the name) are these: He was born at Rain in Bavaria in 1572; he was appointed municipal advocate in Augsburg in December of 1612, and died unmarried in March of 1625. He was of the Catholic faith, and is buried in the Dominican cemetery in Augsburg. His epitaph speaks of him as "learned in the law, experienced in the stars, measurer of the heavens, studious investigator in all pertaining to antiquity." His great work set a new style in star maps; it bears the title, *Uranometria, Omnium Asterismorum Continens Schemata, Nova Methodo Delineata, Aereis Laminis Expressa.*

In 1602, Tycho had published his *Progymnasmata,* a catalogue of 777 stars, with their positions determined with an average error of only about half a minute of arc. Not many students know that while Tycho was very anxious to improve the knowledge of the positions of the stars (the average errors of Hipparchus and Ptolemy were of the order of four minutes of arc), he showed a great indifference to accurate magnitudes, and largely copied the values from Ptolemy's *Almagest.*

Bayer's atlas contains the positions of all of Ptolemy's and Tycho's stars, and those of about 500 additional stars, as well. He made his own estimates of the brightnesses of these latter stars, but for those of Tycho he copied the positions and the magnitudes! This is all very well stated by B. A. Gould, in his *Uranometria Argentina* (1879). Gould's discussion can be read in the section dealing with Bayer in *A Source Book in Astronomy,* by Shapley and Howarth (McGraw-Hill, 1929), a very wonderful book to have on one's shelf. So we should cease complaining that Bayer has assigned some letters in incorrect sequence of brightness; he had apparently no intention of assigning the letters in a strict order of brightness, and even if he had, the brightnesses used were those of Ptolemy, by way of Tycho; and Hipparchus, Timocharis, Aristillus, and Ptolemy must be blamed, not Bayer.

Gould says this: "The system which he adopted for his notation was not, as has been supposed by many, that of assigning the letters in the constellation in the alphabetical order corresponding to the order of brightness of the several stars. On the contrary, as Argelander has conclusively shown, Bayer made no attempt at other discrimination of the relative brightness of the stars, than according to the six orders of magnitude, which had been transmitted from antiquity. For the stars of each order, the sequence of the letters in no manner represented that of their brightness, but depended upon the position of the stars in the figure; beginning usually at the head, and following its course until all the stars of that order of magnitude were exhausted. The non-recognition of this rule, and of the fact that the magnitudes of Ptolemy's and Tycho's stars were taken directly from the *Almagest* and *Progymnasmata,* has led to numerous false theories . . . ." The most conspicuous of these false theories is, of course, the idea that Castor must have been brighter than Pollux, in Bayer's day. Ptolemy had called them both of 2nd magnitude, Bayer copied him, and lettered first the preceding star of the two.

As Gavin J. Burns pointed out in the *Journal* of the British Astronomical Association (November, 1929), one can, by studying the lists and illustrations in the *Source Book* referred to above, discover that in the great majority of cases the letter given by Bayer corresponds to the order in which Ptolemy listed the star.

The title page of the first edition of Bayer's "Uranometria," published in 1603. Reproduced from the copy in the Widener Library, Harvard University.

The stars are arranged by Bayer in groups, each of which consists of stars of the same magnitude, while the stars in each group are arranged in Ptolemy's order. Bayer ran down through the groups, from top to bottom, with the Greek letters in order. Only among the faint stars, for which he made his own estimates of position and brightness, do we find obvious differences from Ptolemy.

A number of strange things have been said about Bayer's work. To quote Gould: "The simple and important advance, of so delineating the constellations as to permit the maps to be compared directly with the face of the sky, rather than with a fictitious outer surface of the imaginary celestial sphere, would seem to be such as to commend itself to the favor of all astronomers; yet such was not the case . . . . Even now it is customary for popular treatises on astronomy to quote the ill-advised remark of Montucla, that Bayer probably erred from overlooking the inversion produced by printing from an engraved plate . . . ."

In Basil Brown's book, mentioned above, the frontispiece depicts the earliest manuscript map of the heavens; it is the so-called Planisphere of Geruvigus, and dates from the 2nd century A.D. The original is in the British Museum, as an illustration in a manuscript copy of the *Phaenomena* of Aratos. In this map no stars are shown, but the constellation figures are drawn in, and they occupy the positions in which we see them as we look into the heavens, and not as they appear on a globe. Bayer was apparently reviving an early custom, and throwing aside the inconvenient scheme which had prevailed for at least a dozen centuries.

R.K.M.

CLEVELAND ASTRONOMICAL SOCIETY

The meetings of the society are held at the Warner and Swasey Observatory, Taylor and Brunswick Roads, East Cleveland, Ohio, at 8:00 p.m. Future lectures are:

March 26: *Stars Brought Down to Earth*—Dr. N. E. Wagman, Allegheny Observatory

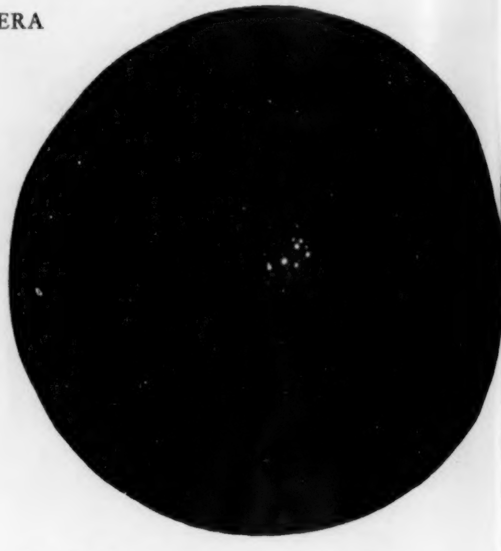
April 23: *The Milky Way*—Dr. S. W. McCuskey, Warner and Swasey Observatory

May 21: *Stellar Spectra*—Dr. W. W. Morgan, Yerkes Observatory

Information about membership with this active group of amateurs may be obtained from Mrs. Royce Parkin, secretary-treasurer, the Cleveland Astronomical Society, c/o the Cleveland Club, Cleveland, Ohio.

GLEANINGS FOR A. T. M.s

AN 8-INCH F/1.5 SCHMIDT CAMERA



This 3-minute exposure with Mr. Waitkus' Schmidt shows the Pleiades and some of the surrounding nebulosity. Uranus appears 5/16″ from the lower left edge, and as far below two stars close together.

BEFORE construction of my Schmidt camera was begun, information and suggestions were gathered from many sources, including The SKY, *Scientific American*, *A.T.M.*, *A.T.M.A.*, Harold Lower, of San Diego, Cal., and Dan McGuire, of Shady Side, Ohio.

It was finally decided to make the camera an f/1.5, with a 12½-inch Pyrex primary, focal length 12 inches, and a 9-inch (8-inch clear aperture) correcting plate. This last was made of ¼-inch glass. The film holder is adapted to a film of 3⅝ inches diameter and provided for a curvature of field of 12-inch radius. The mask to hold the film down to curve reduces the picture size to 3¼ inches. The full field of view is 12 degrees.

Constructing the Primary Mirror. The Pyrex blank was roughed out with No. 80 carborundum, the work having been done on a bench corner for a few hours with a 9-inch cast-iron tool. The blank was then mounted on a vertical spindle running at about 50 r.p.m.; about 45 hours of grinding were necessary before I reached full curve.

For fine grinding, a full-sized cast-iron tool was machined to a radius of 24 inches, and about 40 hours of grinding were required. Polishing was done with a honeycomb full-sized lap, the final stages being carried out with a full-sized pitch lap.

Correcting Plate. The correcting lens of Crystallex from the Pittsburgh Plate Glass Company was ground on the spindle at the same speed, 50 r.p.m., glass tools of ½- and ¾-inch diameter being used. About seven hours of grinding were required. After each period of grinding, I spread thin oil over the fine-ground surface, and wiped all surplus oil off with my fingers, trying to leave as thin a film as possible on the ground surface. This made it transparent enough to see the slits. Final complete polish required about nine hours, using various sizes of pitch lap.

Testing. A test lamp was made, with a 7-watt frosted bulb. The bulb was mounted in a metal box, pierced by a ¼-inch hole in front of the filament. Over this hole I fastened a small piece of glass upon which was pasted a piece of tin foil in which a dozen vertical slits had been cut with a razor blade.

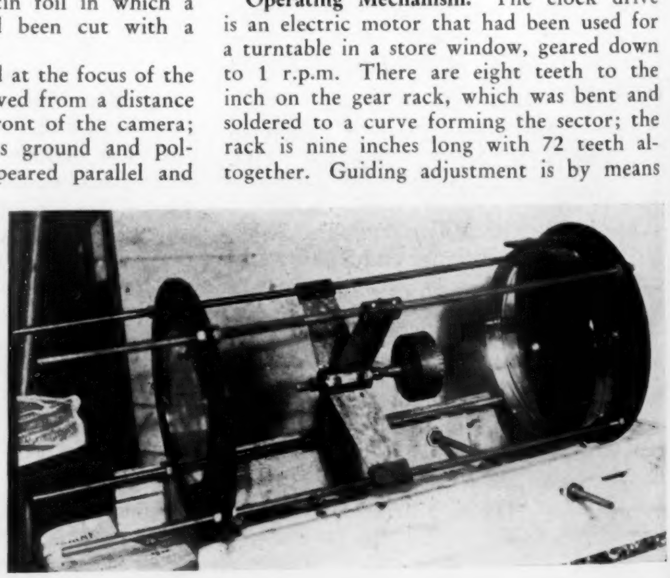
This grid was mounted at the focus of the primary mirror and viewed from a distance of eight or 10 feet in front of the camera; the correcting plate was ground and polished until the slits appeared parallel and straight. Without the correcting plate, pincushion distortion is evident.

Mounting. The tube is an old steel water boiler, with the ends cut off, finished in gray enamel; it is 15 inches in diameter and 31 inches long. It is mounted on a cast-iron fork which rotates in a wooden base cradle. The northern end of the polar axis rests in a Timken roller bearing, which in turn fits into a cast-iron collar, this being bolted to the base cradle. The southern end of the axis turns on a stud in a plain ⅝-inch bushing. The base cradle is fastened with carriage bolts.

The primary mirror is mounted in an old cell that once held a 4-inch portrait lens. The cell just fits into the end of the tube and is held in place with three short screws in the side of the tube.

A total weight of 378 pounds is distributed as 100 pounds in the fork, 82 in the base cradle, and 196 in the tube and accessories.

Operating Mechanism. The clock drive is an electric motor that had been used for a turntable in a store window, geared down to 1 r.p.m. There are eight teeth to the inch on the gear rack, which was bent and soldered to a curve forming the sector; the rack is nine inches long with 72 teeth altogether. Guiding adjustment is by means



The correcting plate in the grinding stage, film holder, and primary mirror of the Schmidt. See the article, "The Saga of Nick's Schmidt," on page 16.

EDITED BY EARLE B. BROWN

of a threaded rod, so placed and geared to a rod and knurled knob that a quarter turn will bring the star back on the cross hairs while the motor is driving the camera.

The motor that operates the shutter is mounted on the back end of the tube with a rod extending from motor to top shutter. Under the rod near the end of the tube is a limit switch which stops the motor on each half revolution. The shutter opens in five seconds by pressing a button on the end of the electric cord—the motor starts, makes a half revolution, the rod then contacts the limit switch and stops the motor when the shutter is wide open. To close the shutter, I press the button on the end of the electric cord—the motor starts, makes another half revolution, the rod then contacts the limit switch and stops the motor when the shutter is closed. Top and bottom shutters are so connected that they open and close together.

For focusing, the film holder is on the end of a threaded rod, which screws in and out of the spider. Star images outside of focus are circles of light—those farther out are larger circles. Inside of focus, the star images are disks, but I kept photographing until I got to the point just in between where the stars are in focus as sharp points.

Accessories. A 4-inch f/7 reflecting telescope is used for guiding, and this is mounted on slip rings for convenience. A 2-inch f/4 refractor is provided as a finder. (See photograph on page 16.)

Results. Although the field of view is 12 degrees, a magnifying glass shows the star images more than four degrees from the center to be fuzzy, so there are eight degrees of good definition. I get lots of sky fog here in Pittsburgh, so to keep the fog at a minimum I am going to use red gelatin filters next to the film.

NICHOLAS J. WAITKUS
124 Watson Blvd., N.S.
Pittsburgh, Pa.

Sauce for the Gander

READERS are asked to send in questions, from which this editor will select the best each month to answer here. The last question is left unanswered, but the reader should be able to find the answer for himself. This month's questions came from Miss Caryl Annear, of Ocean Grove, N. J.

Q. Why does an inclination of 164° for the orbit of a planet or satellite make its motion *retrograde*? (See The SKY, October, 1941, page 9.)

A. On a floor just below a ceiling light, mark a circle to represent the orbit of the earth, and put an arrow on it to show the direction of revolution. Cut out a similar circle in cardboard, also with an arrow. This represents the orbit of another planet. When you hold the orbit horizontal (inclination 0°), with the arrow in the same direction as the circle on the floor, its shadow is a circle and the direction is *prograde*—the same as that of the earth. Now gradually incline the orbit and the shadow becomes an ellipse, but retains the same direction as the marked circle. When the inclination reaches 90° the shadow is a straight line, and the direction is neither prograde nor retrograde. As you continue the inclination of the orbit beyond 90°, the shadow is once more elliptical, but the shadow of the arrow is now pointing in the opposite direction to the arrow on the floor and the motion would be retrograde.

Q. How is this inclination derived? From the perpendicular to the plane of the orbit?

A. The inclination may be measured as an angle between planes or between axes; the results are the same. In the case of a planet, it is easiest to visualize as the angle between the plane of its orbit and the ecliptic.

Q. Just how is retrograde motion expressed?

A. The direction of the earth's rotation in space, from west to east, is counterclockwise as seen from the north; the direct motion in its orbit is the same; retrograde motion is clockwise as seen from the north.

Q. What planets and satellites have retrograde motion?

ANSWER TO LAST QUESTION LAST MONTH: The lithosphere is the main body of the earth, and is surrounded by the hydrosphere and the atmosphere.

L. J. LAFLEUR

The Starry Heavens in March

By Leland S. Copeland

Amateurs That Discovered Planets—An Astronomical Swear Word—Knights in White Armor Who Fought to Keep Men Free

THE only constellation in which two planets were discovered rides high in the night dome of March. It is Gemini, formed chiefly by two lines of stars, one topped by the bright triple sun of Castor and the other by the more brilliant, though solitary, Pollux.

As amateurs we can be proud that Uranus was discovered by Herschel when he was still a beginner and that Pluto was found by Clyde W. Tombaugh when he was only an observatory novice.

In 1781, while Herschel was sweeping with his telescope, he chanced upon Uranus. He was then so inexperienced that he thought he had caught a comet. It was necessary for two professionals, Maskelyne and Lexell, to tell him what an achievement he had made, just as the expert studies of Lampland and Slipher were needed before Tombaugh's accomplishment could be announced.

Pluto was glimpsed first at Lowell Observatory, which is 1,000 feet higher than Mt. Wilson. In March, 1930, when the news was released, Tombaugh told this story to an Associated Press reporter:

"How would you feel if you saw a new world giving you the high sign from beyond the rim of the solar system? That is what happened to me in the dark room when I was running another bunch of photo-plates through the machine. Just a strange flicker of starlight in a routine day's work. Excited? I should say so. I just didn't know what to do or think. Sure, I was the first to see it, but the whole Lowell staff has been working on it for a quarter of a century. I was just lucky."

Pluto was found near δ Geminorum, at the elbow of the starry figure called Pollux, and Uranus was first seen near η Geminorum, in the foot of the bent line named Castor. Eta is close to the summer solstice and the open cluster M35, a nest of 120 stars.

Notice that Castor and Pollux are constellation figures, as well as stars. They are the Heavenly Twins of the zodiac, and they stand at its highest point, from which the sun looks down at us on June 21st.

Castor and Pollux, natives of Sparta, were sons of Zeus and Leda. Their sister was Helen, whose beauty caused the 10-year war before Troy, and their niece was Hermione, "lovely as golden Aphrodite."

The Twins won popularity by rescuing Helen after she had been kidnapped by Theseus. Next they joined the Argonauts, who quested for the golden fleece of Aries. In a storm, on the outward journey, Orpheus played to calm the winds and the sea. Then on the heads of Castor and Pollux sparkled stars, the first St. Elmo's fires. So thereafter sailors swore by the Twins, as we do today when we say, "Jiminy," a colloquial rendering of Gemini. On the return journey they added to their fame by slaying a brass giant in Crete. Too bad that they could not have been there in 1941, to dispose of the Nazi paratroopers.

In a petty war Castor lost his life. Pollux, lonesome and sorrowful, asked Zeus to bring back the lost brother and even offered himself as a substitute. So their divine father, in pity, took them to Olympus and honored them in the zodiac by giving their name to the dual constellation.

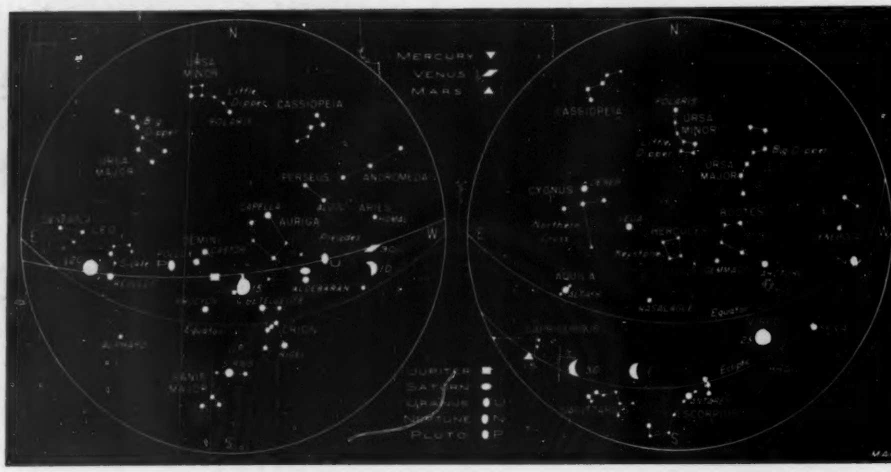
Once in the legendary days of Rome the Twins descended to help men fight for freedom. Whoever will read carefully Macaulay's spirited lay, *The Battle of Lake Regillus*, will feel personally acquainted with Castor and Pollux.

The tyrannical Tarquins, backed by 60,000 men from 30 Latin cities, tried to regain the throne of Rome. While the fierce strife was still indecisive, Aulus, the Roman commander, prayed to the Twins for aid. Almost at once appeared two horsemen in snow-white armor and mounted on milk-white steeds. Their presence greatly stimulated the Romans and equally alarmed the enemy. Speedily the 30 divisions were beaten back and the schemes of the Tarquins forever foiled.

In honor of the Great Twin Brethren, and to commemorate this victory, a temple was built near Vesta's shrine in the Forum. So they were glorified on earth as previously they had been exalted in the heavens.

Among the marvels of Gemini are N.G.C. 2392, a planetary, 20″ by 13″; Castor, the triple, two whites and a red; δ, a white star with red companion; and ζ, a wide double, yellow and blue.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is marked for each five days by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury is too close to the sun for good observation.

Venus, in Pisces, is in the evening sky. Its gibbous shape will show clearly with optical aid.

Mars is in the southeastern sky at sunrise.

Jupiter, the brightest object in the evening sky, sparkles in Gemini.

Saturn remains in Taurus, becoming gradually less bright through the month.

Uranus is in Taurus. (See diagram on the January "Observer's Page.")

Neptune. See diagram on the "Observer's Page."

DEEP-SKY WONDERS

Positions of noteworthy objects referred to on these pages:

Planetary in Gemini: N.G.C. 2392, 7^h 26^m, $+21°$ 02′; small in common telescopes.

Clusters in Puppis: N.G.C. 2422, 7^h 32^m, $-14°$ 16′; N.G.C. 2423, 7^h 32.5^m, $-13°$ 38′; M46, 7^h 37.2^m, $-14°$ 35′; M93, 7^h 40.4^m, $-23°$ 38′; N.G.C. 2477, 7^h 48.7^m, $-38°$ 17′; N.G.C. 2539, 8^h 6^m, $-12°$ 32′.

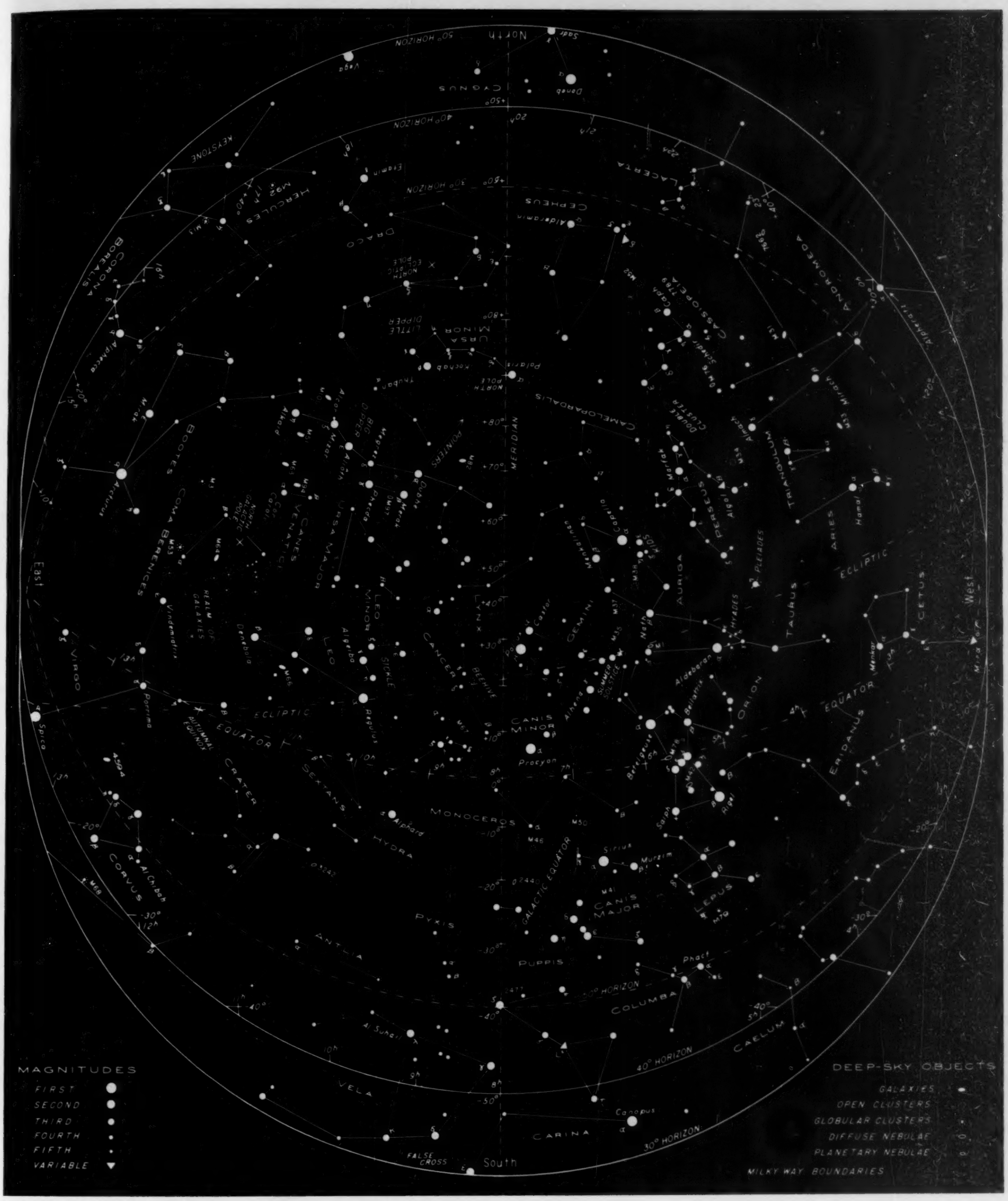
SEEIN' THINGS AT NIGHT

HIDDEN in the constellations are fossils of human thought. As we look this month at Puppis, the sparkling stern of the great ship Argo, we may be seeing also the sacred ark of Sumerian and Biblical story.

The prow is missing. In its place E. W. Maunder, author of *Astronomy of the Bible*, has sketched a mountain. You will recall that the ark rested on Ararat. But the Planisphere of Geruvigus (see "Astronomical Anecdotes," page 17) shows a blank space at the bow instead of a mountain or of the cloud pictured at that spot by Albrecht Dürer (1515), Peter Apian (1536), and Edmond Halley (1675).

If Argo really is a lost memorial for Noah's ark, the story of the Deluge entered the sky from Babylonia. Centaurus, adjoining Argo on the east, once may have been Noah, or Utnapishtim, as the Mesopotamian epic calls him. Clutched in his right hand, or spitted on the spear that he holds, is a beast, says Aratos; a rabbit, according to Geruvigus; or a wolf, Lupus, as our modern atlases disclose. East of Lupus, but separated from it by little Norma, is Ara, the Altar, on which the beast was sacrificed after Utnapishtim stepped out on the mountain top.

Of the birds that were sent forth from the big boat, the raven is resting on the



back of near-by Hydra, and the Dove, a starry figure added in 1661 by Jacob Bartsch, is below Orion and Lepus.

Here, then, is a group of six constellations that seems to recall the Deluge story, told first by Sumerians, treasured by the Babylonians and Assyrians, and glorified by the authors of *Genesis*. In Babylonia, archeologists have found a thick layer of sediment deposited about 4000 B.C. by a great Euphratean flood. This major calamity was remembered for many centuries and at last immortalized in literature, and perhaps in the stars.

Note specially Naos (ζ Puppis), a 2nd-magnitude sun. It forms the fork of a starry Y having α and β of Pyxis at the eastern tip, π of Puppis at the western end, and γ of Vela at the bottom. Puppis is famous for its handsome open clusters: M46, 150 stars with a planetary; M93, near the top of the prow; N.G.C. 2477, beautiful, with 300 stars; and at least five more that merit an amateur's consideration.

THE STARS FOR MARCH

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern war time.

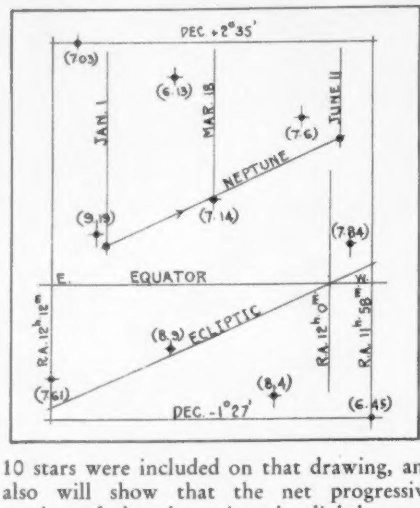
NEPTUNE'S PATH

THE path of the planet Neptune for the first half of 1943 will be in a field of stars all of which are fainter than can be seen with the unaided eye. The diagram shows 10 of these stars, and the magnitude of each is noted. The motion of the planet is retrograde until June 11th. Neptune is in the constellation of Virgo.

The size of the field in the diagram, approximately 3.5 by 4 degrees, can be contained easily in ordinary 6- or 8-power binoculars. However, the faintness of a majority of the stars will necessitate holding the binoculars absolutely rigid.

On March 18th, the planet will be two minutes of arc north of 52 B Virginis, magnitude 7.14. This very close conjunction will enable the amateur to identify Neptune, and its magnitude of 7.7 will cause it to be slightly fainter than the star.

Only two of the 10 stars are shown on the better-known star charts. These are 10 Virginis, magnitude 6.13, and 31 B Virginis, magnitude 6.45. An examination of the diagram in *Sky and Telescope* for February, 1942, will show that six of the



10 stars were included on that drawing, and also will show that the net progressive motion of the planet is only slightly more than two degrees from June 8, 1942, to June 11, 1943.

Neptune will be in opposition to the sun on March 22nd, when its distance from the earth will be 2,721,000,000 miles, or 29.26 astronomical units.

SPRING AND FALL BEGIN

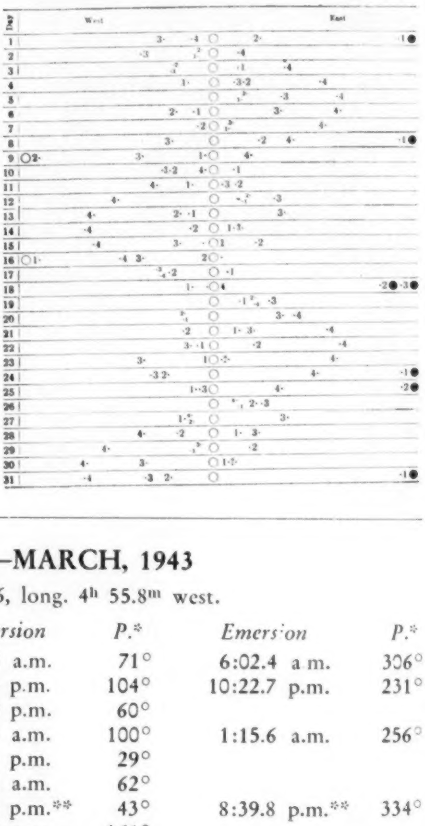
The sun will arrive at the vernal equinox, R.A. 0^h, Dec. 0°, at 8:03 a.m., March 21st. It will be in the constellation Pisces, which it entered on March 13th.

JUPITER'S SATELLITES

On March 4th, 18th, and 25th, the four principal moons will be east of the primary. On the 16th before 8:05 p.m., on the 30th before 11:52 p.m., and on the 31st after 11:19 p.m., they will be west of the primary. The configurations on the 4th, 30th, and 31st will show the moons in numerical order, with *I* nearest the primary.

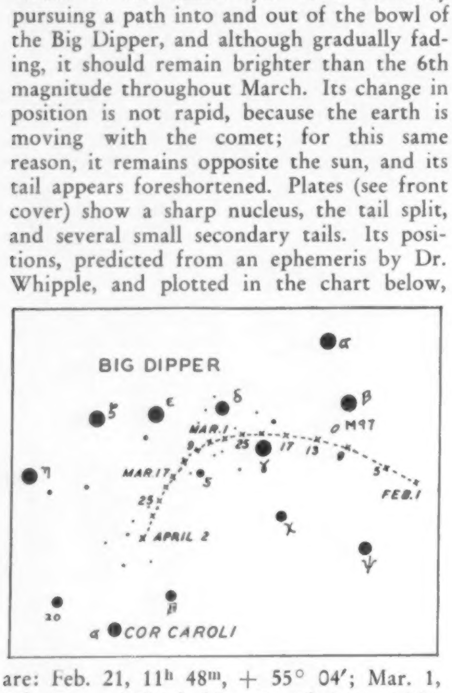
On March 1st, the eclipse disappearance of *IV* at 7:05 p.m. and the transit ingress of *I* and *II* at 7:10 and 7:43 will leave Jupiter attended by only one satellite until the egress of *I* at 9:25. *III* will be very near western elongation at this time.

Jupiter's four bright moons have the positions shown below at 12:15 a.m., E. W. T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris.



WHIPPLE'S COMET

Early in February, Whipple's comet was nearly as bright as the 4th magnitude, easily visible to the naked eye. It is currently pursuing a path into and out of the bowl of the Big Dipper, and although gradually fading, it should remain brighter than the 6th magnitude throughout March. Its change in position is not rapid, because the earth is moving with the comet; for this same reason, it remains opposite the sun, and its tail appears foreshortened. Plates (see front cover) show a sharp nucleus, the tail split, and several small secondary tails. Its positions, predicted from an ephemeris by Dr. Whipple, and plotted in the chart below,



are: Feb. 21, 11^h 48^m, + 55° 04′; Mar. 1, 12^h 10^m, +54°54′; Mar. 9, 12^h 24^m, +53° 46′; Mar. 17, 12^h 34^m, + 51° 53′; Mar. 25, 12^h 40^m, +49° 25′; Apr. 2, 12^h 43^m, +46° 30′.

PHASES OF THE MOON

New moon ....March 6, 6:34 a.m.
First quarter ....March 13, 3:30 p.m.
Full moon ....March 21, 6:08 p.m.
Last quarter ....March 28, 9:52 p.m.

MINIMA OF ALGOL

March 7, 11:54 p.m.; 10, 8:43 p.m.; 30, 10:28 p.m.

NOVA PUPPIS 1942

The spectacular nova which appeared early in November in the constellation of Puppis has now become a late evening rather than a just-before-dawn object. To be sure, it now requires optical aid to be seen, and for northern observers it is still low near the southern horizon.

Although the nova faded rapidly in brilliance during the first few weeks after discovery, the variation in light during January and February was slight. The star is hovering around magnitude 6.5, visible in a good pair of binoculars or a small telescope.

A chart showing the position of the nova and surrounding stars appeared on page 5 of the December *Sky and Telescope*.

LEON CAMPBELL

OCCULTATIONS—MARCH, 1943

Local station, lat. 40° 48′.6, long. 4^h 55.8^m west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
Mar. 1	6.3	39 G Sagittarii	4:59.0 a.m.	71°	6:02.4 a.m.	306°
10	5.9	BD + 11° 445	9:25.4 p.m.	104°	10:22.7 p.m.	231°
12	7.2	BD + 16° 657	8:18.9 p.m.	60°		
13	5.7	318 B Tauri	0:18.6 a.m.	100°	1:15.6 a.m.	256°
13	6.9	BD + 18° 950	11:01.3 p.m.	29°		
14	7.0	BD + 18° 987	1:54.8 a.m.	62°		
16	5.1	ζ Cancri	7:48.5 p.m.**	43°	8:39.8 p.m.**	334°
18	7.5	BD + 15° 1984	0:46.7 a.m.	166°		
24	5.8	13 Librae	11:12.1 p.m.	121°	0:17.0 a.m. (25)	284°

* P is the position angle of the point of contact on the moon's disk measured eastward from the north point.
** Time given is for the close pair—see note below.

The star ζ Cancri is a binary and will be noted on our double star list next month. The *A* or primary star is itself a binary with a separation of approximately 1″, too close to be resolved by the average amateur telescope, especially so near to the moon's glare as during this occultation. The time given above is for the mean of this pair. The *B* star will be occulted about 15 seconds later at our local station.

Some stars of magnitudes fainter than 6.5 have been included in the above list. The times are based on the *a* and *b* quantities in the supplementary list of occultations recently issued by the Nautical Almanac Office, and are for immersions only at the dark limb. These fainter stars are listed because of the serious need for more occultation reports.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for transplanted amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	BOND AST. CLUB	1st Thu.	8:15	Oct.-June	Harvard Obs.	Homer D. Ricker, Harvard Observatory
"	A.T.M.S OF BOSTON	2nd Thu.	8:15	Sept.-June	Harvard Obs.	C. S. Cook, 16 Belfry Terr., Lexington
BROOKLYN, N.Y.	ASTR. DEPT., B'KLYN INST.	Rd. Table 3rd Thu.	8:00	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N.Y.C., *BA.* 7-9473
BUFFALO	A.T.M.S & OBSERVERS	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	BURNHAM A. S.	2nd, 4th Tue.	8:00	Sept.-June	Congress Hotel	Miss W. Sawtell, 928 N. Harvey Ave.
CINCINNATI	CIN. A.A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	CLEVELAND A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH	D. B. STARGAZERS	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	DETROIT A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	NORTHWEST A.A.S.	1st, 3rd Tue.	8:00	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	DULUTH AST. CLUB	1st, 3rd Sat.	8:00	All year	Darling Obs.	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	TEX. OBSERVERS	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	INDIANA A.A.	1st Sun.	2:00	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	JOLIET A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Monica L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A.S.	3rd Tue.	8:00	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	MAD. A.S.	2nd Wed.	8:00	All year	Washburn Obs.	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	MILW. A.S.	1st Thu.	8:00	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	POP. AST. CLUB	2nd Wed.	7:30	Oct.-April	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	Milton T. Corbett, 47 Canner St.
NEW YORK	A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	JUNIOR AST. CLUB	Alt. Sat.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	EASTBAY A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. OF F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	RITTENHOUSE A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	A.A.A. OF P'BURGH	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 402 Cedarhurst
PONTIAC, MICH.	PONTIAC A.A.A.	2nd Mon.	8:00	All year	Private homes	John Setlow, Jr., 593 S. Paddock St.
PORTLAND, ME.	A.S. OF MAINE	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	AST. STUDY GROUP	1st Mon.	8:00	All year	420-3 Av., Rm. 212	H. J. Carruthers, 427 S. 61 Ave.
PROVIDENCE, R.I.	SKYSCRAPERS	1st Wed.	8:00	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	READING-BERKS A.C.	2nd Thu.	8:00	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A.S. OF NEV.	4th Wed.	....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N.Y.	ROCH. AST. CLUB	Alt. Fri.	8:00	Oct.-May	Eastman Bldg., Univ. of Rochester	M. L. Groff, 400 University Ave.
SAN ANTONIO	SAN ANT. A.A.	3rd Mon.	8:00	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'TADY AST. CLUB	3rd Mon.	8:00	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
STAMFORD, CONN.	STAMFORD AST. SOC.	4th Wed.	8:00	Oct.-June	Stamford Museum	Stamford Mus., 300 Main St.
TACOMA, WASH.	TACOMA A.A.	1st Mon.	....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
TULSA, OKLA.	TULSA A.S.	2nd Tue.	....	All year	Holland Hall	V. L. Jones, 4-8462
WASHINGTON, D.C.	NAT'L. CAP. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	WICHITA A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
YAKIMA, WASH.	YAK. AM. ASTR'MERS	2nd Tue.	7:30	All year	Y.M.C.A. Audit.	J. L. Thompson, 4 S. 10 Ave., 21455

Sky and Telescope is official publication of many of these societies.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *March*, NAVIGATING BY THE STARS.

What do our navigators need to know these eventful days, to reach successfully their targets in Africa, Europe, and the Pacific, and to return safely to their home bases again? Much of their training of course is technical, yet the underlying principles can be grasped by anyone. These form the basis of the Buhl Planetarium's March sky show. We have a graphic and simple explanation of how the navigator uses the sun, moon, planets, and stars in finding his way about, how the motions of the sky are connected with the problems of determining latitude and longitude. We gain also an idea of the instruments essential to the precise celestial navigation of today, which help to make it so different from the crude navigation of Columbus.

This is a time when the airplane has become all-important. This sky show plainly answers the questions which come up in so many people's minds regarding the navigational methods which make long-distance air travel possible.

★ **THE HAYDEN PLANETARIUM** presents in *March*, STARS IN SONG AND STORY. (See page 12.)

In *April*, WEATHER SIGNS IN THE SKY. Weather today is largely a military secret so that we will not give aid and comfort to the enemy. However, there are signs that men have used since long before air masses were heard of. Some of these old weather signs depend upon the appearances of the heavenly bodies. During April we will show and discuss Weather Signs in the Sky.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays)......3 and 8:30 p.m.
Sundays and Holidays........................3, 4, and 8:30 p.m.
(Building closed Tuesdays)

★ STAFF—*Director*, Arthur L. Draper; *Lecturer*, Nicholas E. Wagman; *Manager*, Frank S. McGary; *Public Relations*, John J. Grove; *Chief Instructor of Navigation*, Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation*, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays..................2, 3:30, and 8:30 p.m.
Saturdays ....11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays..................2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Assistant Curators*, Marian Lockwood, Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant*, Fred Raiser; *Lecturers*, John Ball, Jr., Charles H. Coles, Charles O. Roth, Jr.